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ABSTRACT

This second volume of the metrication study report contains the instructional materials developed to help the industrial and vocational education fields to use the metric system, primarily in the area of industrial arts from the seventh through the fourteenth year. The materials are presented in three sections. Section 1, Going Metric in Industrial Education, includes metric materials for career education, for all students, for drafting, for metalworking, for graphic arts, and for woodworking and building construction. Also included are lists of tools and related materials. Section 2 contains materials for teaching metrics in home economics. Section 3 presents samples of instructional materials used during an indepth metric seminar for industrial teacher educators. Most of the packets consist primarily of transparency masters and related outlines for the teacher. (The report of the metrication study including evaluation of these materials is in Volume I.) (MF)

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FINAL REPORT

Volume II of Two Volumes

Project No. V257006
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METRICATION OF TECHNICAL CAREER EDUCATION

JOHN L. FEIRER

The Center for Metric Education
Western Michigan University

Kalamazoo, Michigan 49008

April 1976

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
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Section 1

GOING METRIC IN INDUSTRIAL EDUCATION

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Related Materials

Section 2 -- Going Metric in Home Economics

Section 3 -- Samples of Instructional Material Used During Indepth Metric Seminar, Colorado State University

GOING METRIC FOR CAREER TEACHERS -- NOTES AND COMMENTS

1. ISLANDS IN A METRIC WORLD. The United States is the last major industrial nation to "go metric."
2. THINGS WE MEASURE. Every day billions of measurements are made in industry, commerce, and by the consumer.
3. KINDS OF MEASURING SYSTEMS. The three kinds of measuring systems are:
 1. Customary, commonly called English in the United States and Imperial in the United Kingdom, Canada, Australia.
 2. The old metric system which includes the CGS-centimetre, gram, and second; and MKS-metre, kilogram, and second. Metric units of the metre, gram, litre, and centigrade variety are only 175 years old but are widely used. Many are now inaccurate and imperfect.
 3. SI metric, the international system of measuring units called SI for its basic name--Système International d'Unités--is a modernized version of the metric system established in 1960.
4. THREE MAJOR TYPES OF MEASURING SYSTEMS
5. INTERNATIONAL SYSTEM OF UNITS. There are seven base units and two supplementary units, plus a large number of derived units.
6. OVERLAY FOR INTERNATIONAL SYSTEM OF UNITS. Note that all symbols are lower case except those that were named after important scientists such as the kelvin after Lord Kelvin, a British scientist.

7. PREFIXES, EXPONENTS, AND SYMBOLS. All base units use the same prefixes, exponents, and symbols. The three most commonly used are base unit, one thousand times the base unit, and one-thousandths of the base unit. For example, for length it would be the metre, kilometre, and millimetre.
8. THE FAMILY OF SI METRIC. (first sheet) Here you see four of the brothers--the metre, the kilogram, kelvin, and the mole. Since the kelvin is used only in scientific work, the degree Celsius is used in every-day activities. The litre is called a cousin because it is a derived unit.
9. THE FAMILY OF SI METRIC. (second sheet) Three more of the SI family have been used for many years also in the customary system including the ampere, the second, and the candela. Some of the other derived units include the newton, watt, joule, and pascal.
10. THIS IS THE WAY THAT THE CUSTOMARY (ENGLISH) SYSTEM DEVELOPED. Note that the customary system was based on the human body while the metric system originally was based on the distance from the north pole to the equator.
11. MAN AS A MEASURING ROD. All the original customary units are directly or indirectly related to the human body.
12. MEET BROTHER METRE. no comment
13. I'M BROTHER METRE. Note that the metre is a little longer than the yard.

14. HERE'S HOW THE METRIC MEASURE COMPARES WITH THE FOOT. The inch equals exactly 25.4 millimetres. Four inches would be 101.6 millimetres or approximately 102.
15. NOW STOP AND THINK. Note how the metric system is very similar to our money system. They are both a decimal system and have similar names. The three most commonly used measurements for smaller distances are the metre, the centimetre, and the millimetre. These are very easy to remember in relationship to a dollar, 100 cents, and 1000 mills.
16. THE SMALLEST DIVISION ON ME IS ONE MILLIMETRE. Note how a millimetre is about half way between 16ths and 32nds. Students should begin to get an idea of the actual size of the millimetre.
17. NOW LET'S HAVE A BALL. The metric size could be covered and students would be asked to give the equivalent of the inch size.
18. AND TAKE A LOOK AT YOUR MONEY. The thickness of a dime is a good reference for estimating one millimetre (1 mm) and a nickel for estimating two millimetres (2 mm).
19. A KILOMETRE. In oral conversation note that the emphasis is on the first syllable (kill'-o-metre), not on the second. To place the emphasis on the last syllable is wrong. The kilometre is about 5/8 of a mile.
20. ALL INTERNATIONAL SPORTS ARE IN SI METRIC MEASUREMENTS. Any students watching the Olympics would have heard all measurements referred to in metric terms.

21. WATER GLASS. To begin to think metric, it is a good idea to be able to estimate sizes. What is the diameter of the water glass; how tall is it?
22. MATCH BOX. No comment
23. BASKETBALL PLAYERS. Would a two-metre tall basketball player be a good center?
24. MEET BROTHER KILOGRAM. no comment
25. I'M BROTHER KILOGRAM. no comment
26. KILOGRAM. A kilogram of butter would be a little more than twice a pound. The use of the term "kilo" is incorrect.
27. A KILOGRAM (kg) EQUALS 1000 GRAMS (g). no comment
28. A NICKEL WEIGHS ABOUT FIVE GRAMS. Does the student remember the thickness of a nickel?
29. FOR VERY SMALL WEIGHTS. no comment
30. FOR GREATER WEIGHTS THE METRIC TON IS USED. A metric ton is called the "tonne" in SI metric.
31. MANY GROCERY ITEMS ARE MARKED WITH BOTH CUSTOMARY (ENGLISH) AND METRIC WEIGHT. Is 14 ounces exactly 397 grams?
32. MEET FIRST COUSIN LITRE. no comment
33. MILK. The litre is about 6 percent more than the quart.
34. IN THE METRIC SYSTEM THERE IS A DEFINITE RELATIONSHIP BETWEEN UNITS. It is important to point out to students how valuable this is in learning a new system of measurement. There is no relationship between capacity, mass, weight, and length in the customary system.

35. THREE MEASUREMENTS TO REMEMBER. no comment
36. MEET BROTHER CELSIUS--THE UNIT OF TEMPERATURE. no comment
37. BROTHER CELSIUS TEMPERATURE. Note that the term centigrade is no longer used even though it is commonly found in chemistry and physics books. What would be a good day for skiing in degrees Celsius?
38. 25 DEGREES FAHRENHEIT AND 25 DEGREES CELSIUS. Note that one is a winter scene and the other a summer scene.
39. TEMPERATURE. no comment
40. SISTER SECOND. no comment
41. SISTER AMPERE. no comment
42. SISTER CANDELA. no comment
43. BROTHER MOLE. no comment
44. SIMPLIFIED METRIC EQUATION--CUSTOMARY U.S. EQUATION. Note how easy it is to change in the metric system from larger to smaller units in contrast to the customary system.



THINGS WE MEASURE



Kinds of Measuring Systems

- 1. Customary*
- 2. Metric*
- 3. SI Metric*

Three Major Types of Measuring Systems

- I. Customary System: This is the system of measurement that is predominantly used in the United States. It includes such commonly used units as inch, foot, yard, mile, pint, quart, gallon, pound, degree Fahrenheit, etc.
- II. Metric System: This is a system of measure that applies the metre as the unit of length. Originally, the metre was defined as one ten millionth of the distance between the earth's pole and the Equator. With this system of measurement, though, there were differences found between the nations who use it. Thus, the metric system was not really standard and there was no room for misunderstanding and error for scientific work.
- III. The International System of Units (SI): This is the metric system that has been refined and standardized by a General Conference of Weights and Measures. This standard metric system has been founded on seven basic units which include the metre, kilogram, second, ampere, candela, kelvin, and mole.



INTERNATIONAL SYSTEM OF UNITS (SI)

Seven Base Units

- 1. Metre: Unit of length*
- 2. Kilogram: Unit of mass*
- 3. Second: Unit of time*
- 4. Ampere: Unit of electric current*
- 5. Kelvin: Unit of temperature*
- 6. Candela: Unit of luminous intensity*
- 7. Mole: Unit of amount of substance*

Symbol

m

kg

s

A

K

cd

mol

PREFIXES, EXPONENTS, and SYMBOLS

<u>Decimal Form</u>	<u>Exponent or Power</u>	<u>Prefix</u>	<u>Pronunciation</u>	<u>Symbol</u>	<u>Meaning</u>
1 000 000 000 000	$= 10^{12}$	tera	tě'r' á	T	trillion
1 000 000 000	$= 10^9$	giga	ji' gá	G	billion
1 000 000	$= 10^6$	mega	měg' á	M	million
1 000	$= 10^3$	kilo	kil' ô	k	thousand
100	$= 10^2$	hecto	hěk' tō	h	hundred
10	$= 10^1$	deka	děk' á	da	ten
1					base unit
0.1	$= 10^{-1}$	deci	děs' ĭ	d	tenth
0.01	$= 10^{-2}$	centi	sěn' tĭ	c	hundredth
0.001	$= 10^{-3}$	milli	mĭl' ĭ	m	thousandth
0.000 001	$= 10^{-6}$	micro	mĭ krô	μ	millionth
0.000 000 001	$= 10^{-9}$	nano	năn' ô	n	billionth
0.000 000 000 001	$= 10^{-12}$	pico	péc' ô	p	trillionth
0.000 000 000 000 001	$= 10^{-15}$	femto	fěm' tō	f	quadrillionth
0.000 000 000 000 000 001	$= 10^{-18}$	atto	ăt' tō	a	quintrillionth

most commonly used



The Family of

SI METRIC

4 BROTHERS

- metre
- kilogram
- kelvin(celsius)
- mole

3 SISTERS

- ampere
- second
- candela

1 COUSIN

- litre



FIRST COUSIN litre



BROTHER metre
(length)



BROTHER kilogram
(mass)



BROTHER kelvin(celsius)
(temperature)



BROTHER mole
(amount of
substance)



More of the Family of

SI METRIC

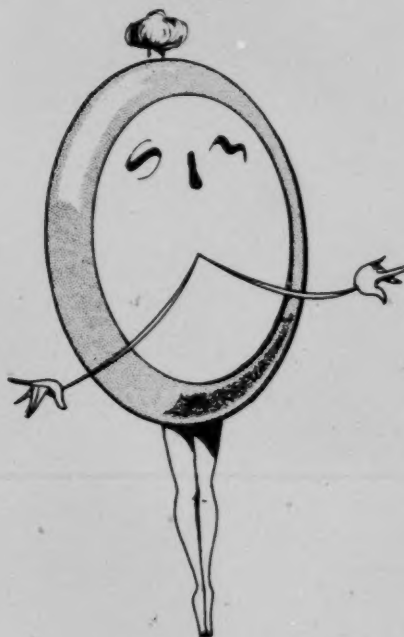
SISTER ampere
(electric current)



SISTER candela
(luminous intensity)



SISTER second
(time)

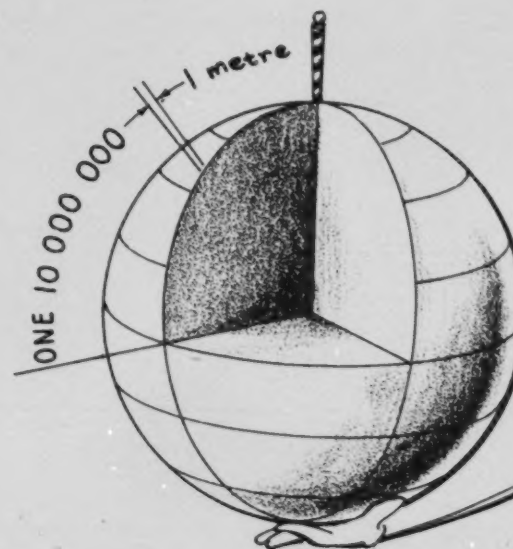


*-and other second cousins -
such as:*

- newton
- watt
- joule
- pascal

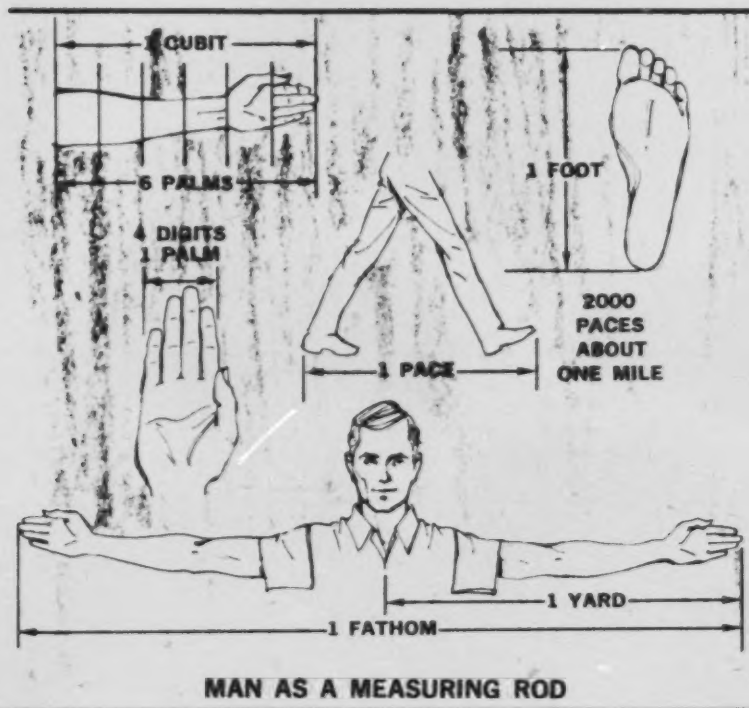


THIS IS THE WAY THAT
THE CUSTOMARY (ENGLISH)
SYSTEM DEVELOPED.



The metre
is equal to
 $\frac{1}{10,000,000}$ of
the distance from
the north pole
to the equator.



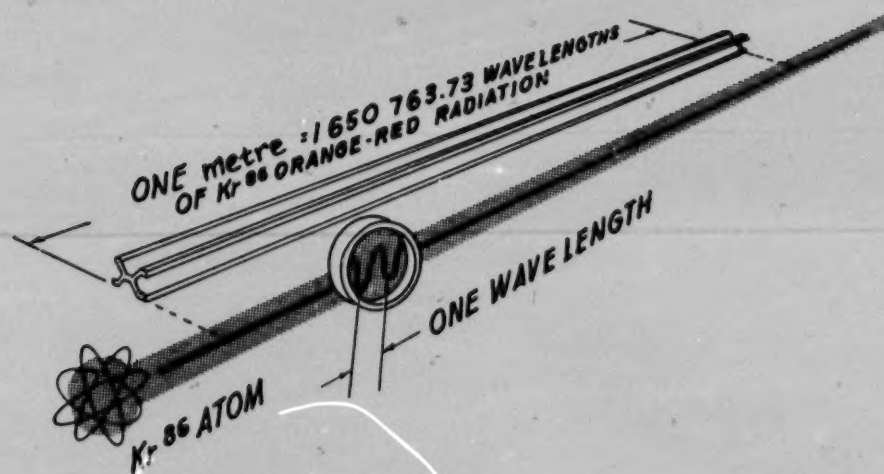




Meet **BROTHER metre** the base unit of **LENGTH**

scientific definition:

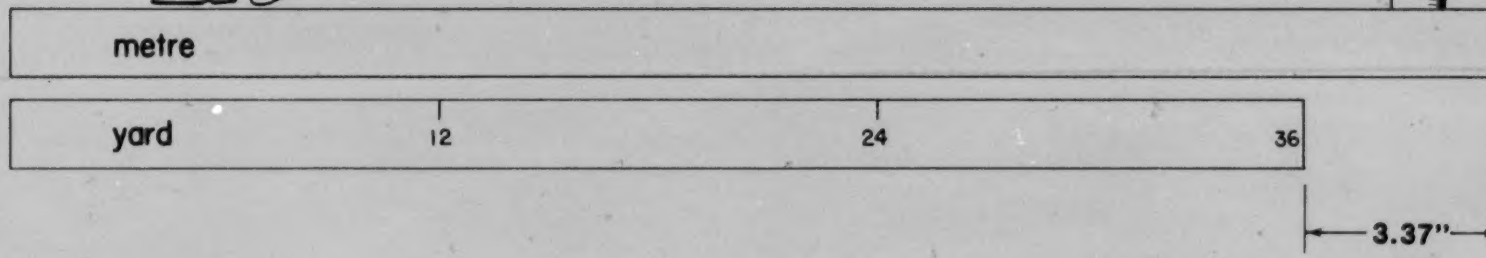
The metre is defined as equal
to 1 650 763.73 wave lengths
of orange-red light given off
by krypton 86.





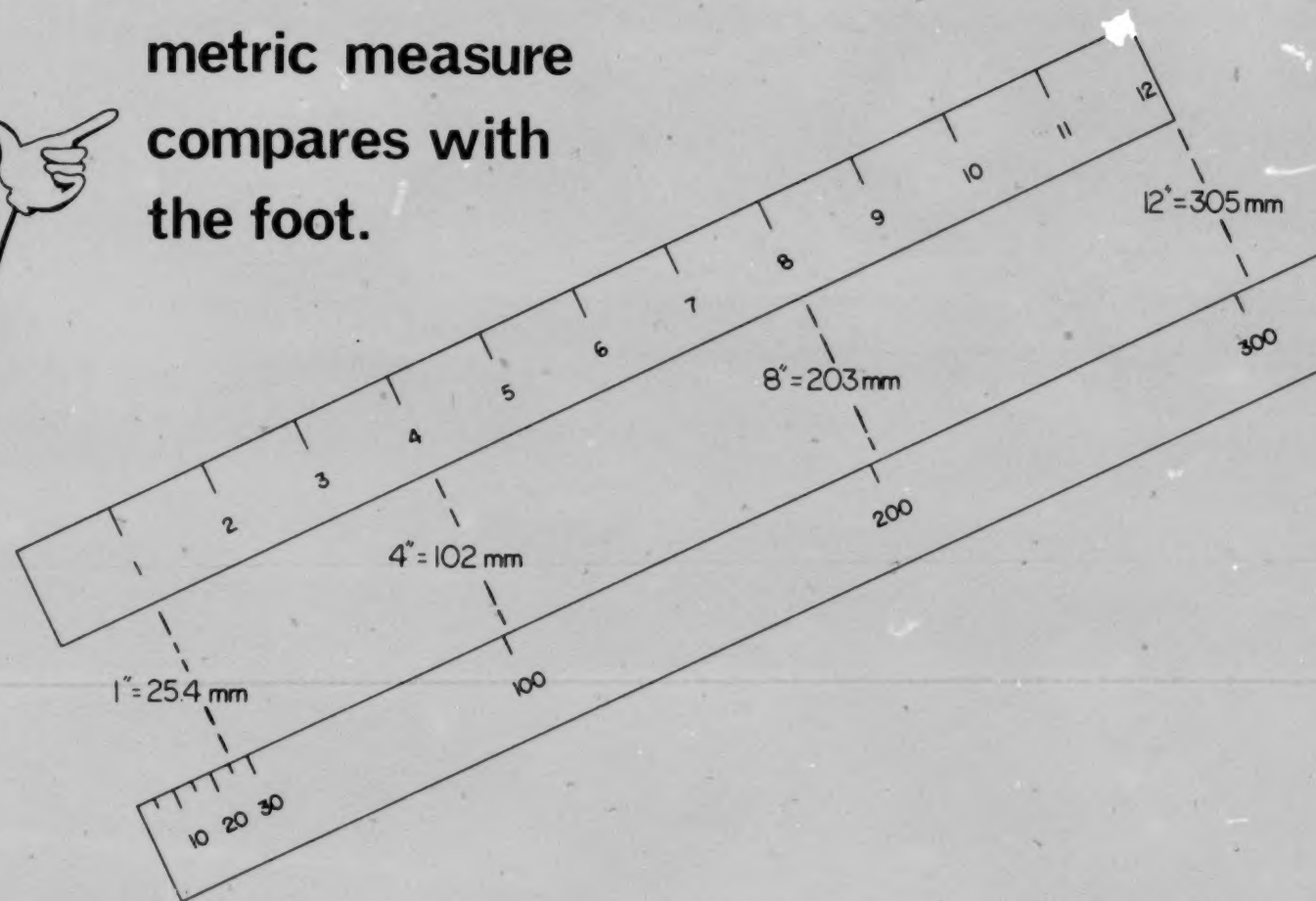
I'm brother **metre-**
a base member of the
SI METRIC family.

I'm a little more than
3 inches longer than
my friend, the yard.





Here's how the
metric measure
compares with
the foot.





Now stop and think

If a dollar

equalled
a metre –



=

metre

then



10 dimes

=

10 decimetres



100 cents

=

100 centimetres



1000 mills

=

1000 millimetres





The smallest division on me is  one millimetre –

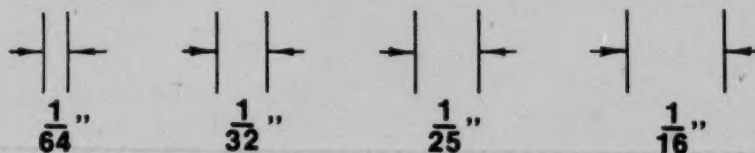
which is equal to exactly $\frac{1}{25.4}$
or about $\frac{1}{25}$ of an inch.

The smallest division on the
customary machinist's rule
is $\frac{1}{64}$ "

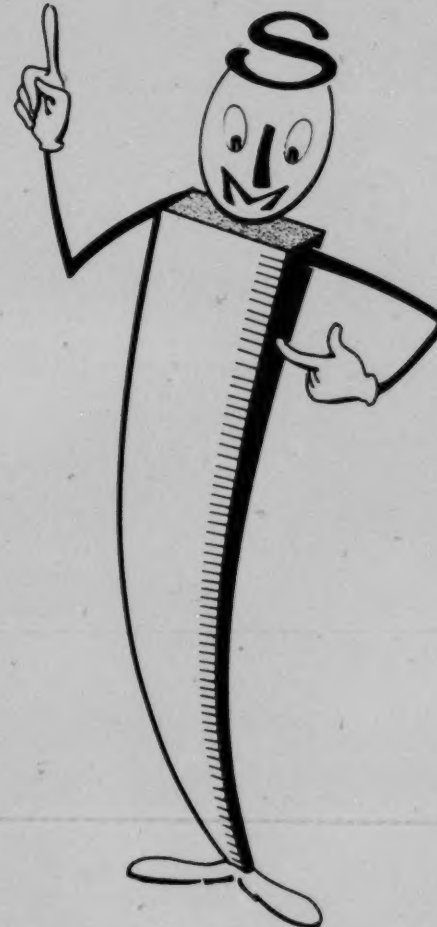
The next smallest is $\frac{1}{32}$ "

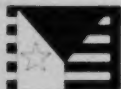
The next smallest is $\frac{1}{16}$ "

A millimetre is about halfway
between the $\frac{1}{32}$ " and the $\frac{1}{16}$ "



(enlarged)





Now

LET'S HAVE A BALL!



PING-PONG BALL



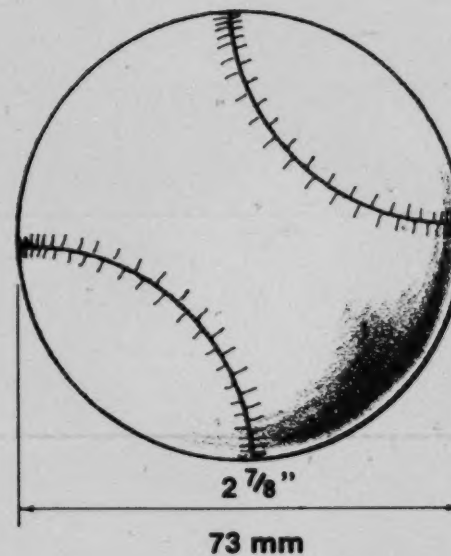
MARBLE

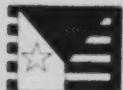


GOLF BALL



BASEBALL





-and

TAKE A LOOK AT YOUR MONEY.

DIME



18 mm



1 mm

CENT



19 mm

**HALF DOLLAR
50 CENTS**



30 mm

NICKEL



21 mm



2 mm

**ONE DOLLAR
100 CENTS**



38 mm

**QUARTER
25 CENTS**



24 mm



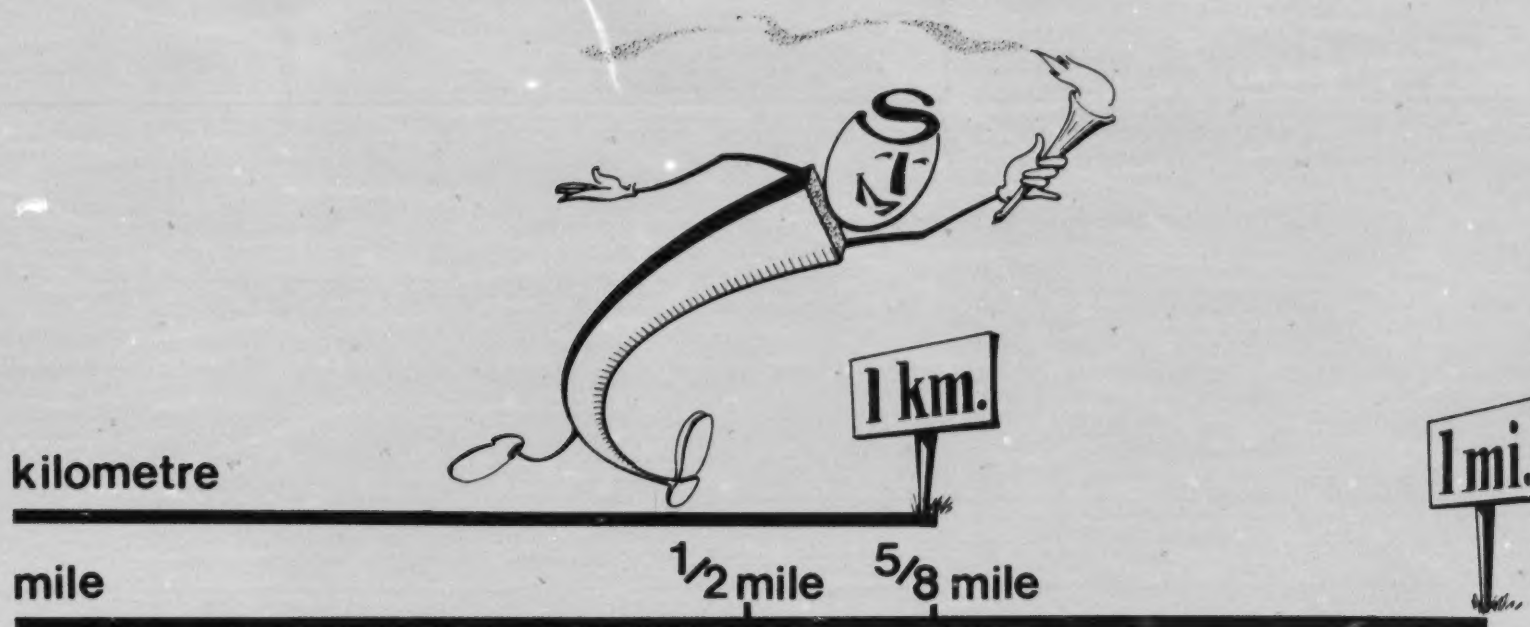


A kilometre

-is used for long distances.

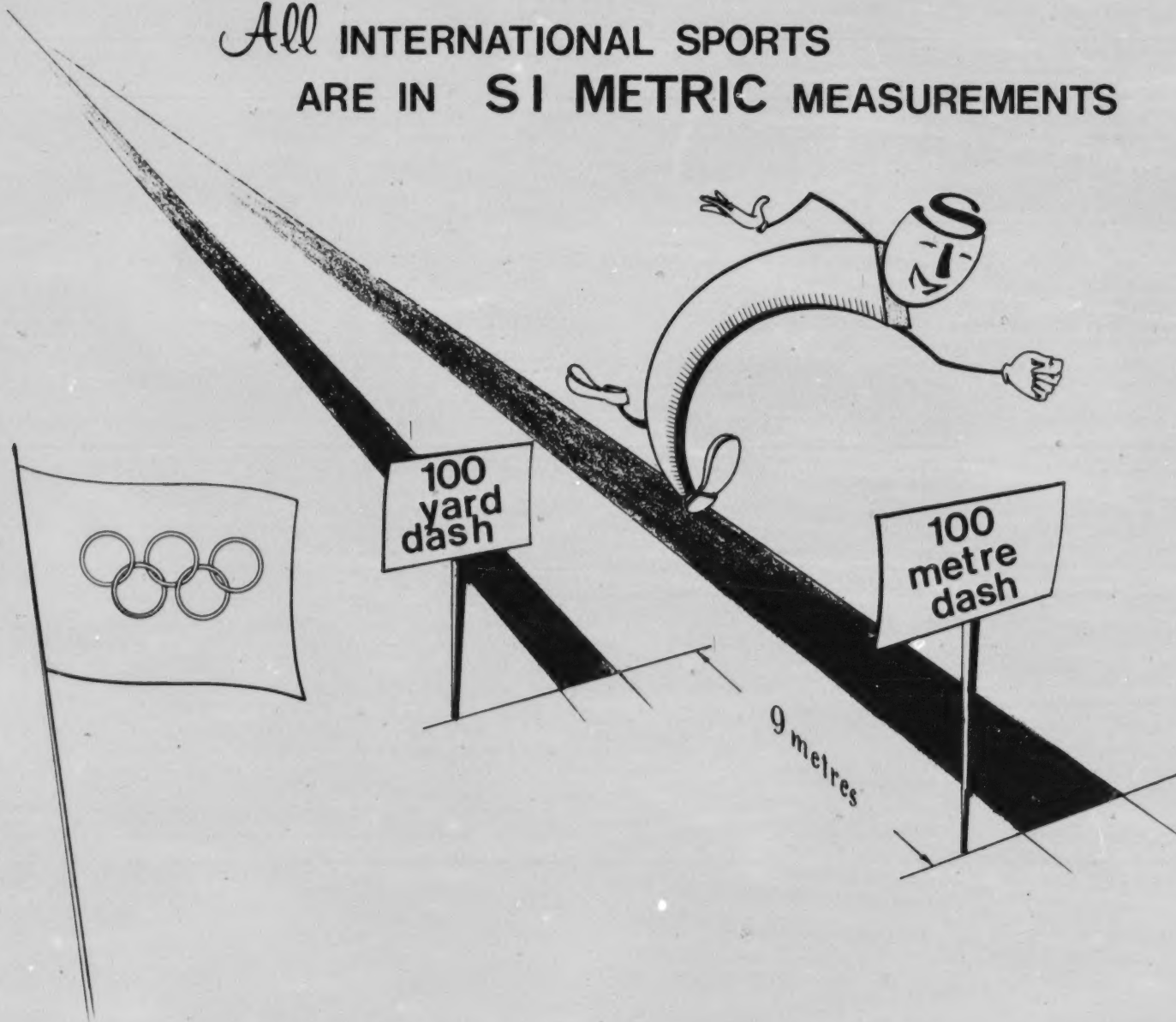
1000 metres equal one kilometre (km).

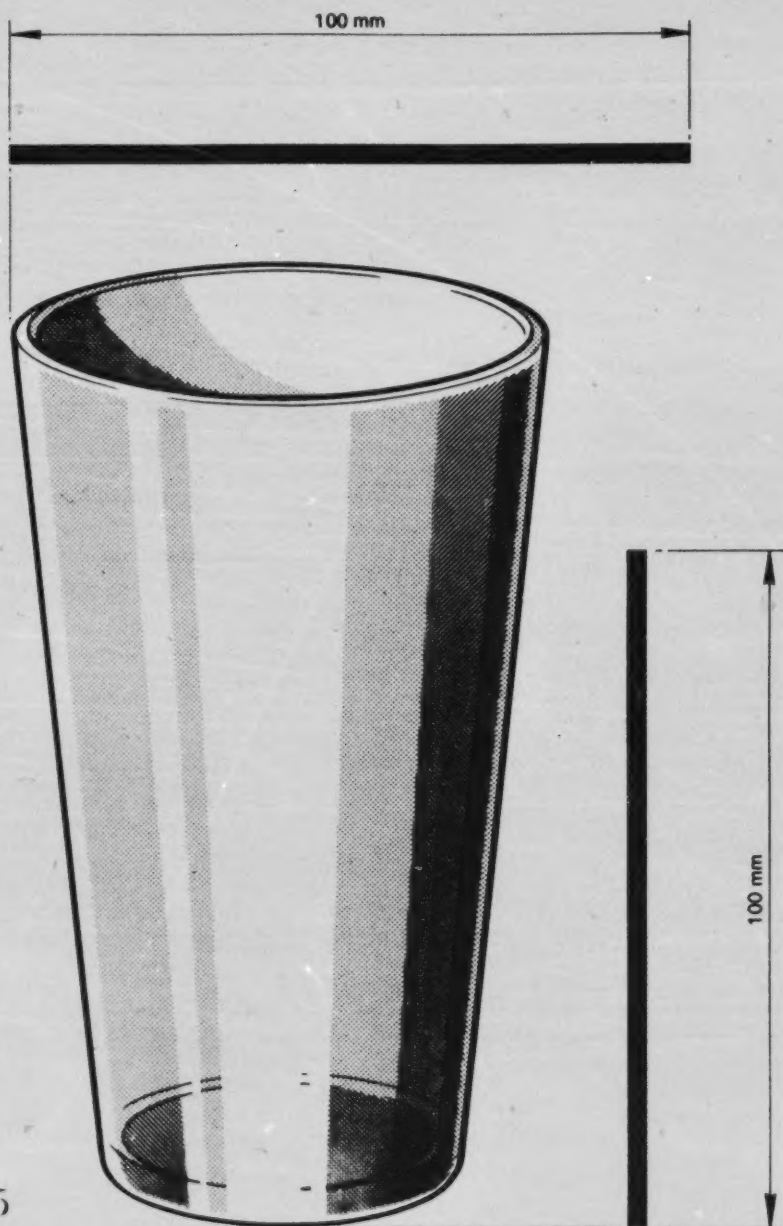
A kilometre is about $\frac{5}{8}$ of a mile.



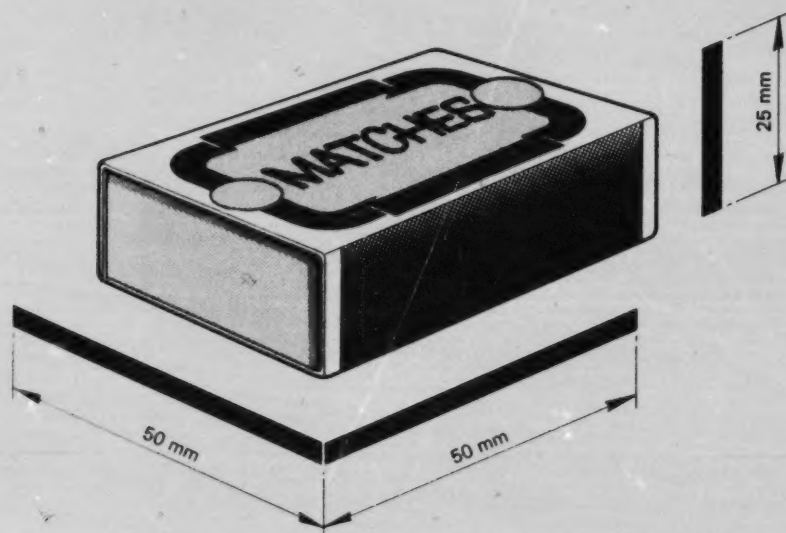


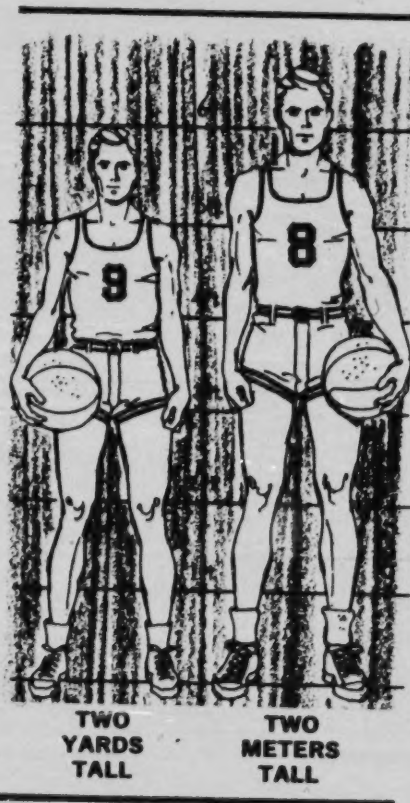
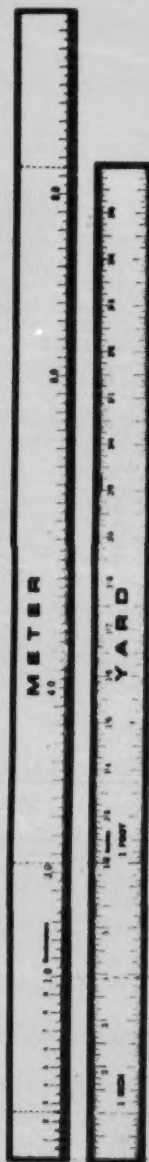
All INTERNATIONAL SPORTS ARE IN **SI METRIC** MEASUREMENTS

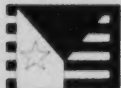




45







Meet **BROTHER** kilogram (kg)

the base unit of mass.

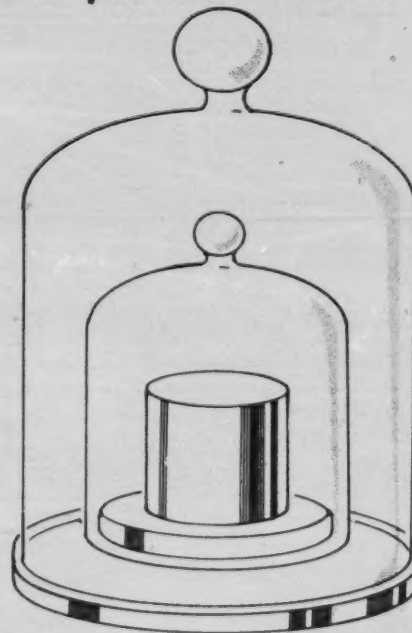
Scientific definition:

The standard for mass is a cylinder of platinum-iridium alloy kept by the International Bureau of Weights and Measures at Paris.

A duplicate U.S. prototype, kilogram No. 20, is in the custody of the National Bureau of standards

The kilogram is the only base unit that employs a prefix kilo.

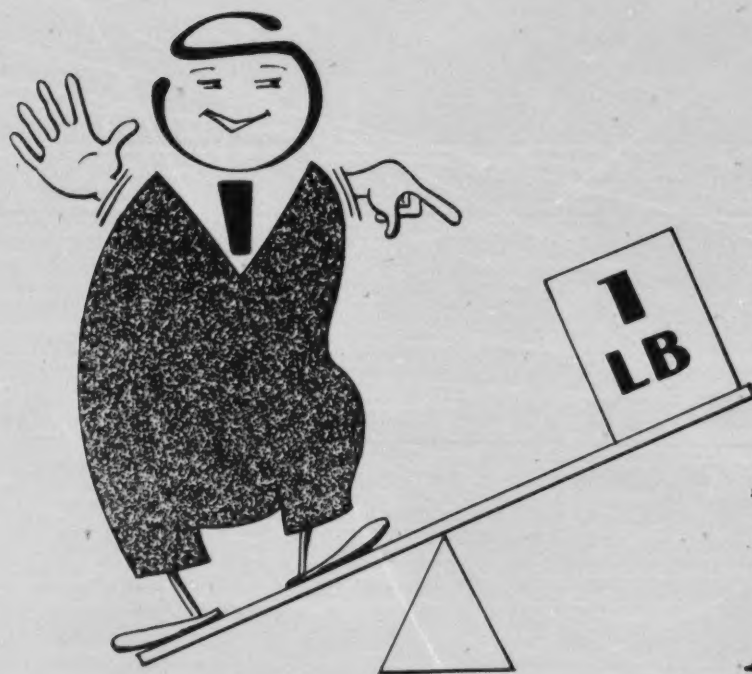
The gram is too small for most practical uses.





I'M BROTHER KILOGRAM

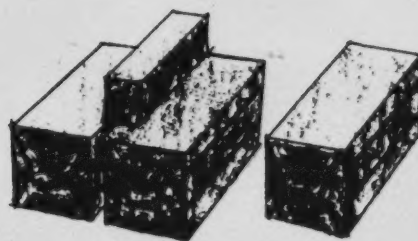
I'm much heavier
than a pound!



I weight about
2.2 pounds.



1 pound = 0.4536 kilograms
1 kilogram = 2.2046 pounds



1 KILO

1 POUND

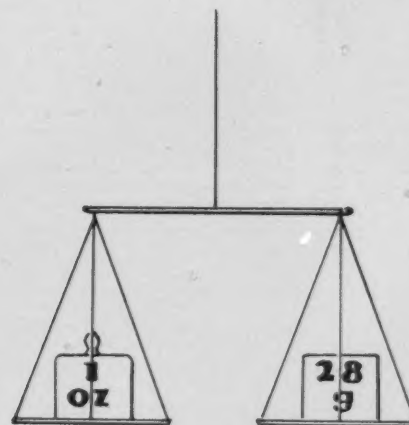
1 Kilogram = 2.204 Pounds



**A kilogram (kg)
equals
1000 grams (g)**



**An ounce equals
about 28 grams**



**1 ounce = 28.35 grams
1 gram = 0.03527 ounces**

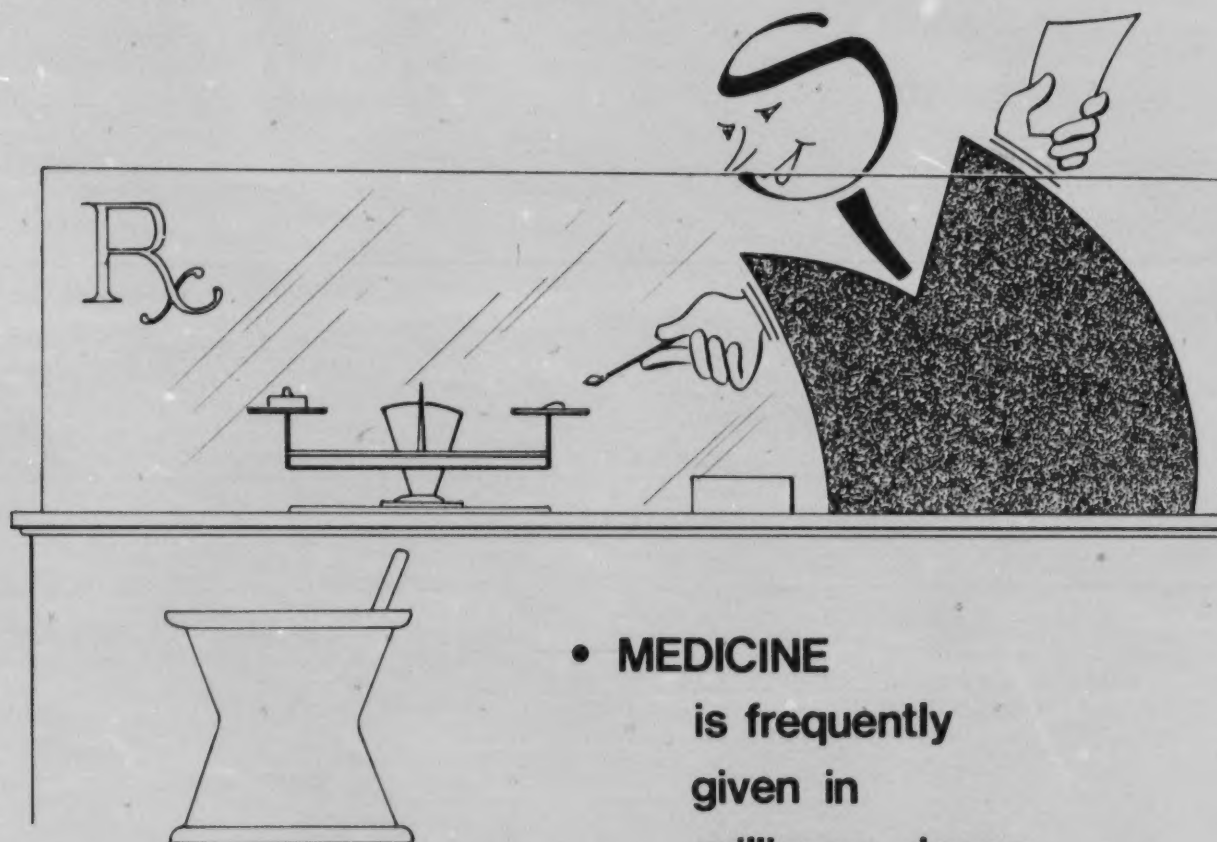


A NICKEL
weighs about
five grams

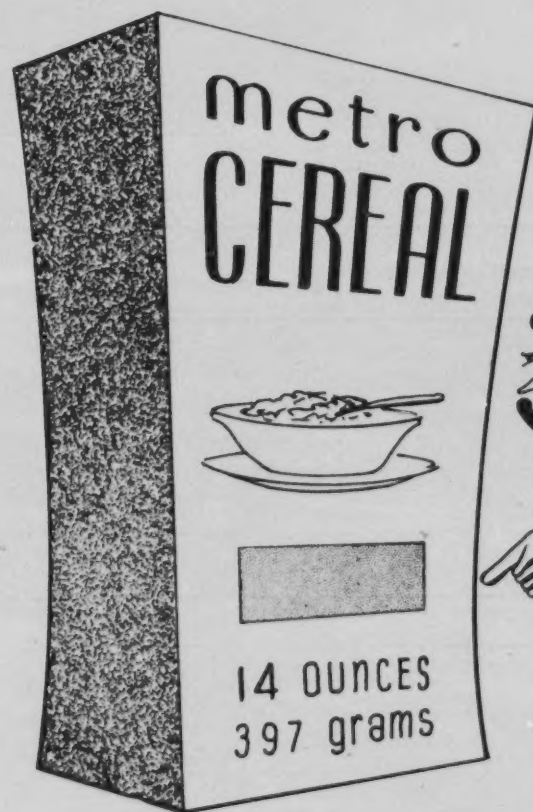




For very small weights
the milligram (mg) is used.
1 milligram = 0.001 gram



- MEDICINE
is frequently
given in
milligram doses.

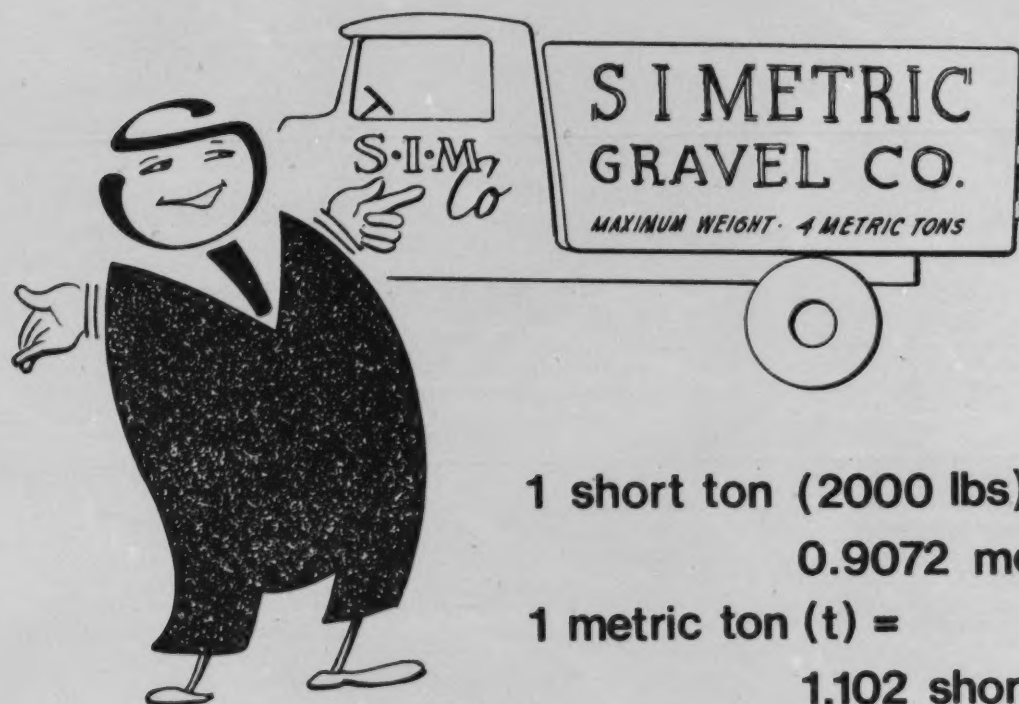


**Many GROCERY ITEMS
are marked with both
customary (English)
and metric weight.**





For greater weights –
the metric ton (t) is used.
1 metric ton = 1000 kilograms
or about 2200 pounds



1 short ton (2000 lbs) =
0.9072 metric tons
1 metric ton (t) =
1.102 short tons



Meet **FIRST COUSIN Litre** the derived unit of volume.

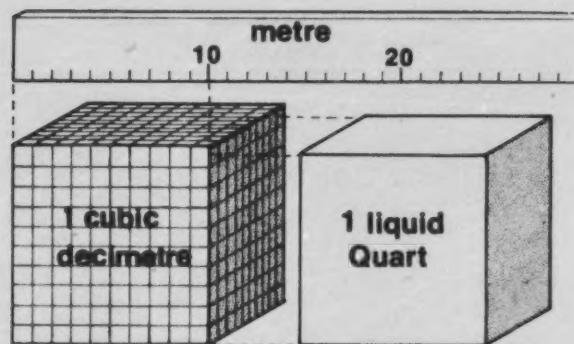
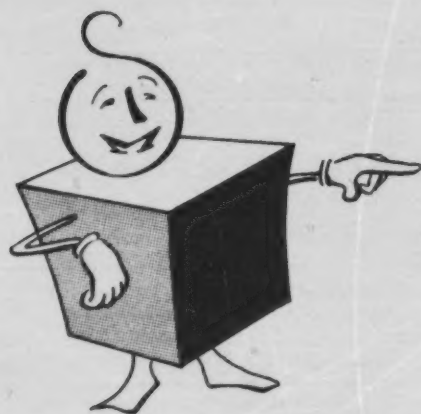
The litre is equal to one cubic decimetre (1 dm^3)

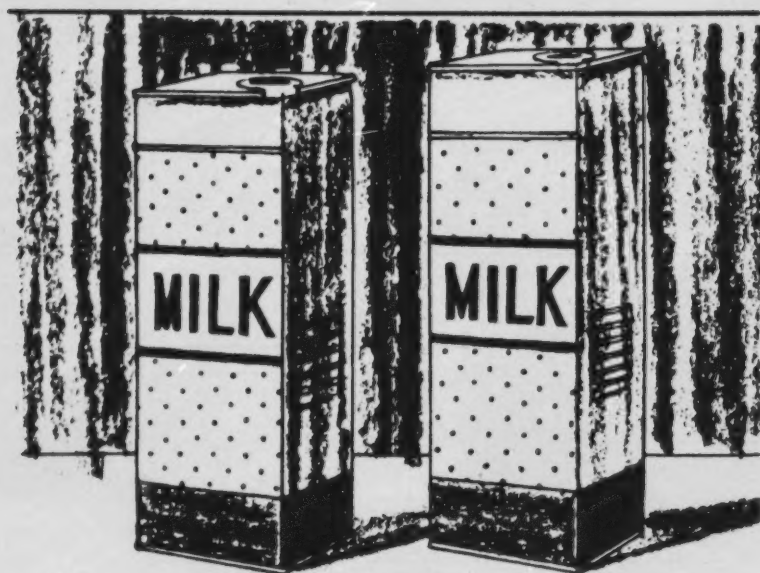
or 1 000 cubic centimetres ($1\,000 \text{ cm}^3$)

or 1 000 000 cubic millimetres ($1\,000\,000 \text{ mm}^3$)

The litre is used for measuring liquids such as water, milk, paint, oil and many others.

The litre is slightly more (about 6%) than a quart.





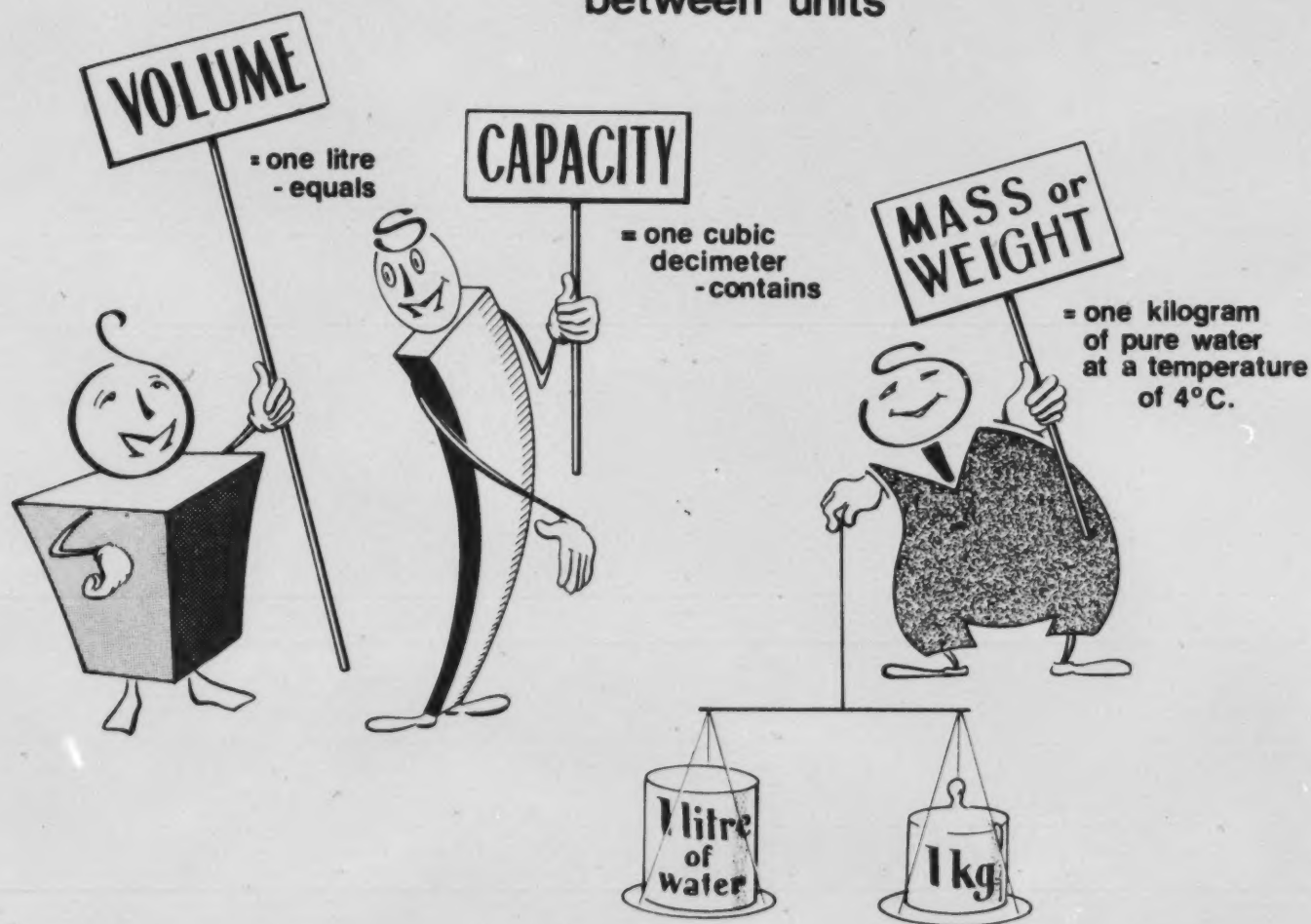
1 QUART

1 LITRE

1 LITRE = 1.057 LIQUID QUARTS



In the metric system
there is a definite relationship
between units

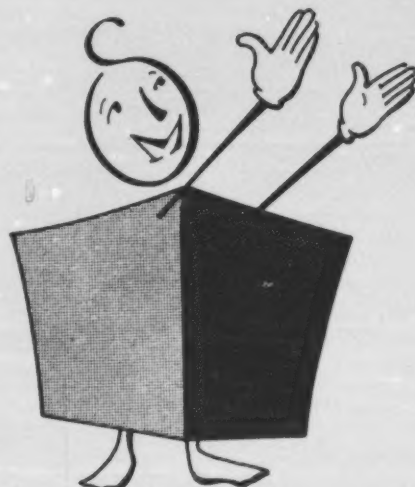




THREE MEASUREMENTS to REMEMBER



THE metre
is a little longer
than a yard —
— 39.37 inches.



THE litre
is a little larger
than a quart
— about 6%

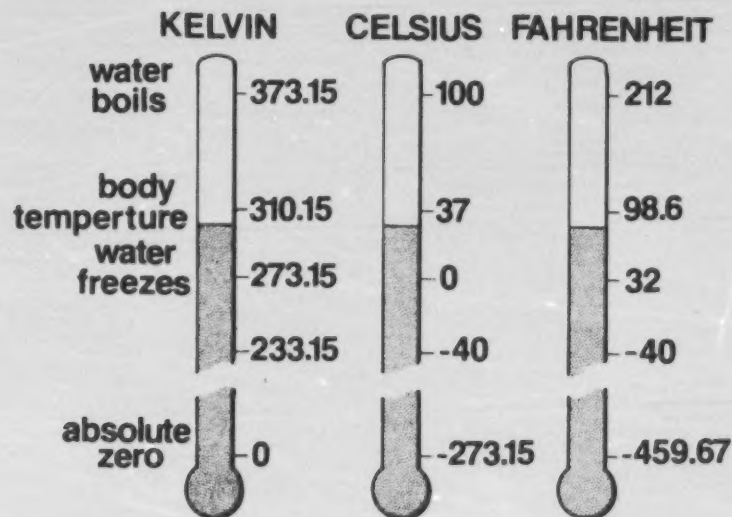
THE kilogram
is a little more
than twice the pound
— 2.2 pounds





Meet **BROTHER Celsius-** the unit of temperature.

In the metric system scientists use the official base unit of kelvin (k) for temperature:
However, the Celsius scale is used for everyday needs.
The Celsius scale is derived from the kelvin scale
and they are related by the exact difference of 273.15 degrees.



$$\begin{aligned} \text{Temp. K} &= \text{Temperature } ^\circ\text{C} + 273.15 \\ \text{Temp. } ^\circ\text{C} &= \frac{\text{Temp. F} - 32}{1.8} \end{aligned}$$

$$\text{Temp. F} = 1.8 (\text{Temp. } ^\circ\text{C}) + 32$$





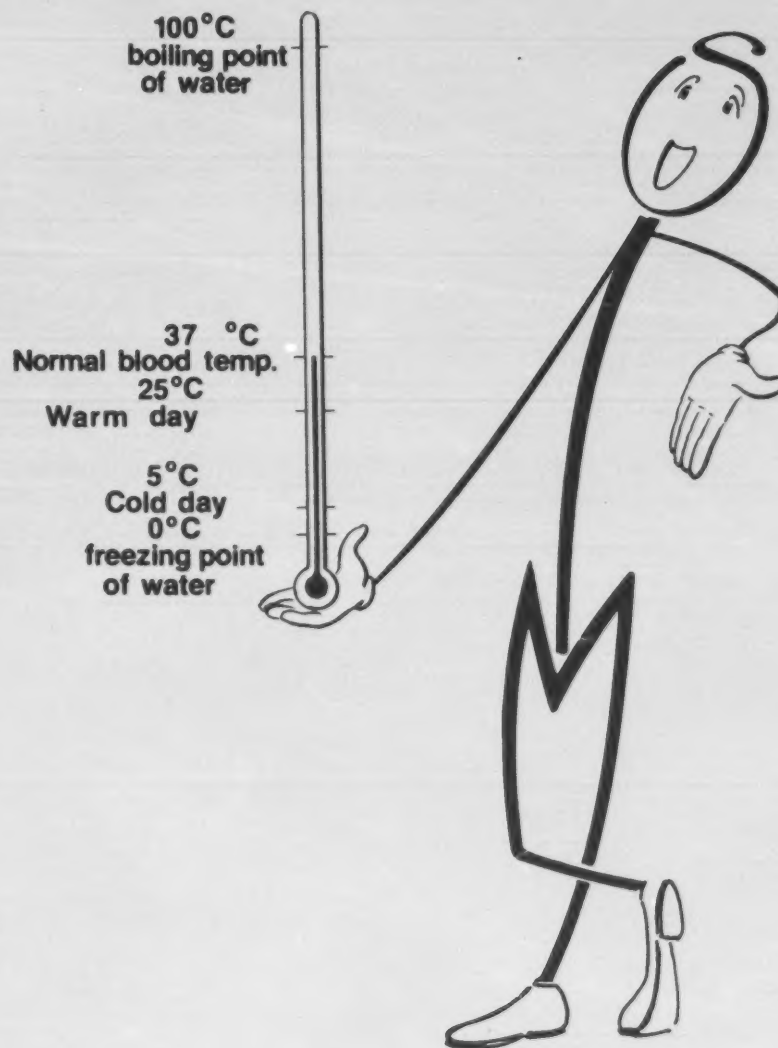
BROTHER Celsius TEMPERATURE

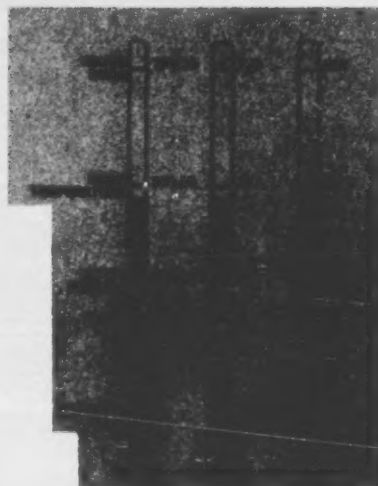
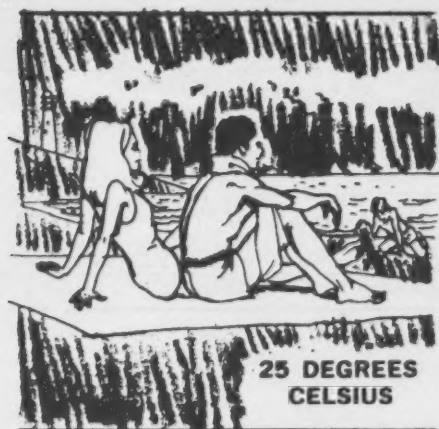
The common metric unit
for **TEMPERATURE** is
the degree Celsius.
It is identical to
the degree Centigrade.

The symbol is $^{\circ}\text{C}$

Two common reference
temperatures are

- 100°C boiling point of water
- 0°C freezing point of water.



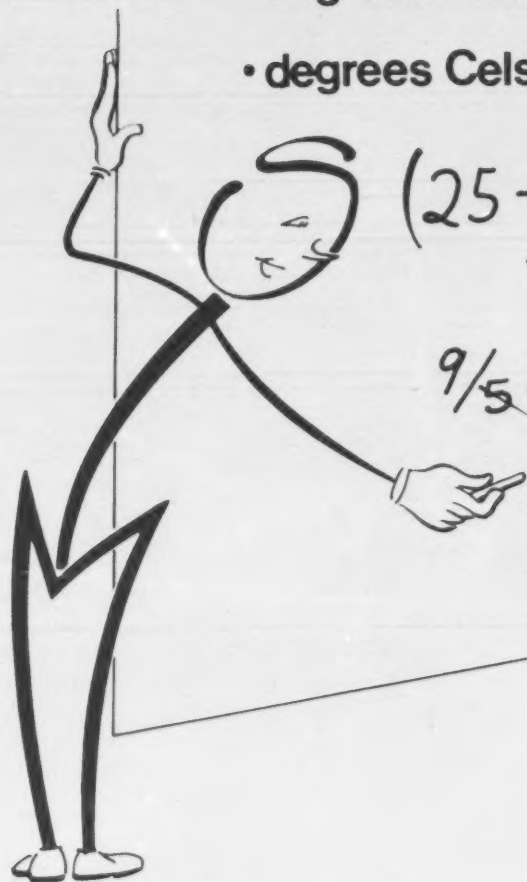




TEMPERATURE

Approximate conversion from Customary to Metric – and vice versa:

- degrees Fahrenheit to degrees Celsius $\cdot 5/9$ (after subtracting 32)
- degrees Celsius to degrees Fahrenheit $\cdot 9/5$ (then add 32)



$$(25 - 32) \times \frac{5}{9} \\ -7 \times \frac{5}{9} = -4^{\circ} \text{Celsius}$$

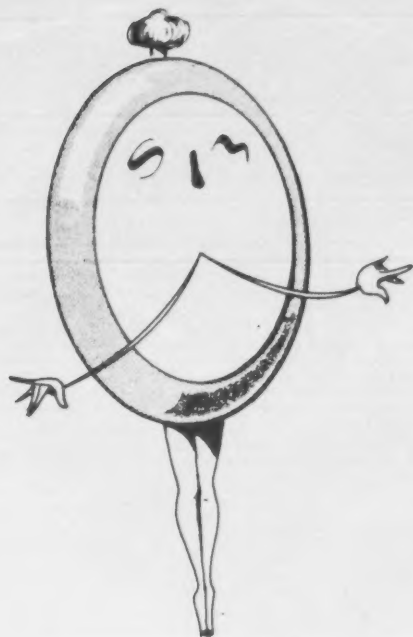
$$\frac{9}{5} \times 25 + 32 \\ 45 + 32 = 77 \text{ Fahrenheit}$$



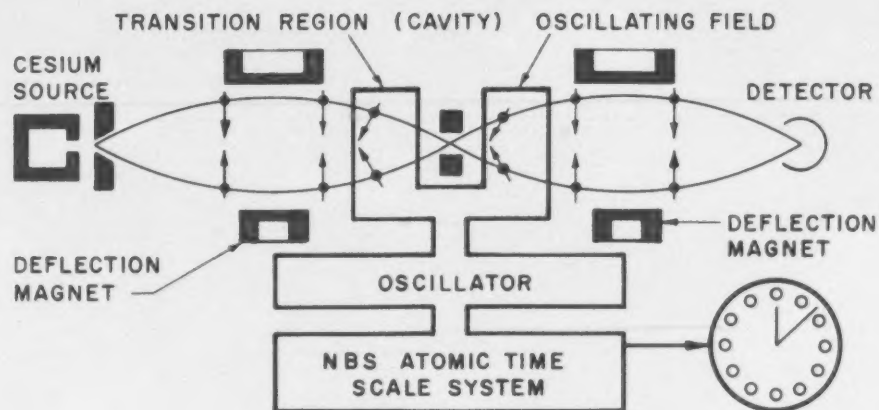


SISTER Second

(time)



The second is defined as the duration of 9 192 631 770 cycles of the radiation associated with a specified transition of the cesium-133 atom. It is realized by tuning an oscillator to the resonance frequency of cesium-133 atoms as they pass through a system of magnets and a resonant cavity into a detector.

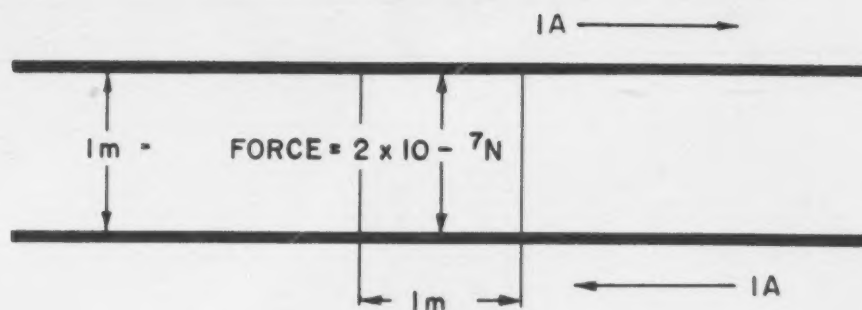




SISTER ampere (electric current)

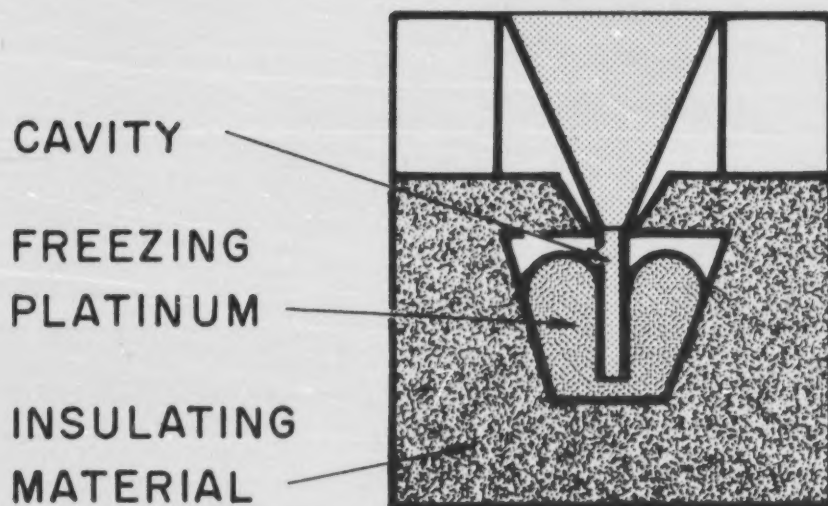


The ampere is defined as that current which, if maintained in each of two long parallel wires separated by one metre in free space, would produce a force between the two wires (due to their magnetic fields) of 2×10^{-7} newton for each metre of length.



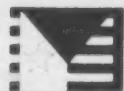


The candela is defined as the luminous intensity of $1/600\,000$ of a square metre of a blackbody at the temperature of freezing platinum (2045 K).



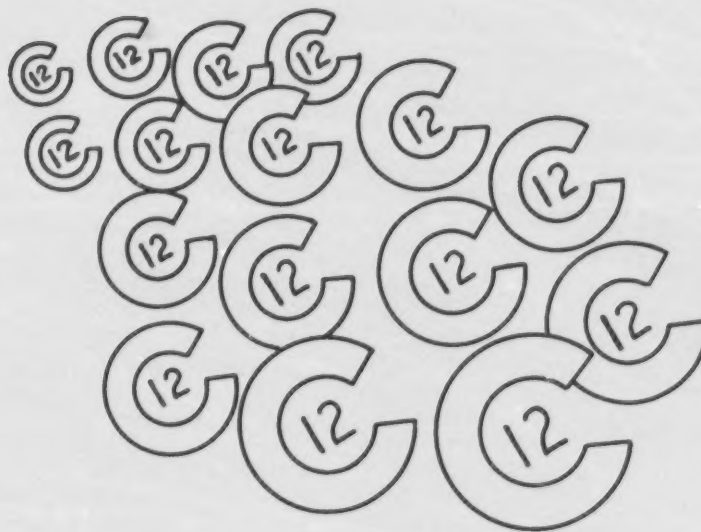
SISTER candela
(luminous intensity)





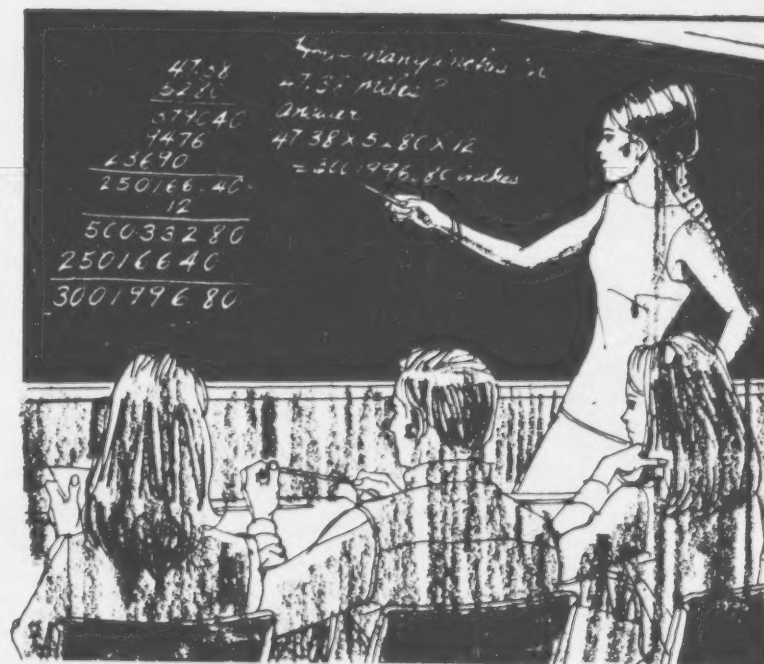
BROTHER mole
(amount of
substance)

The mole is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12.

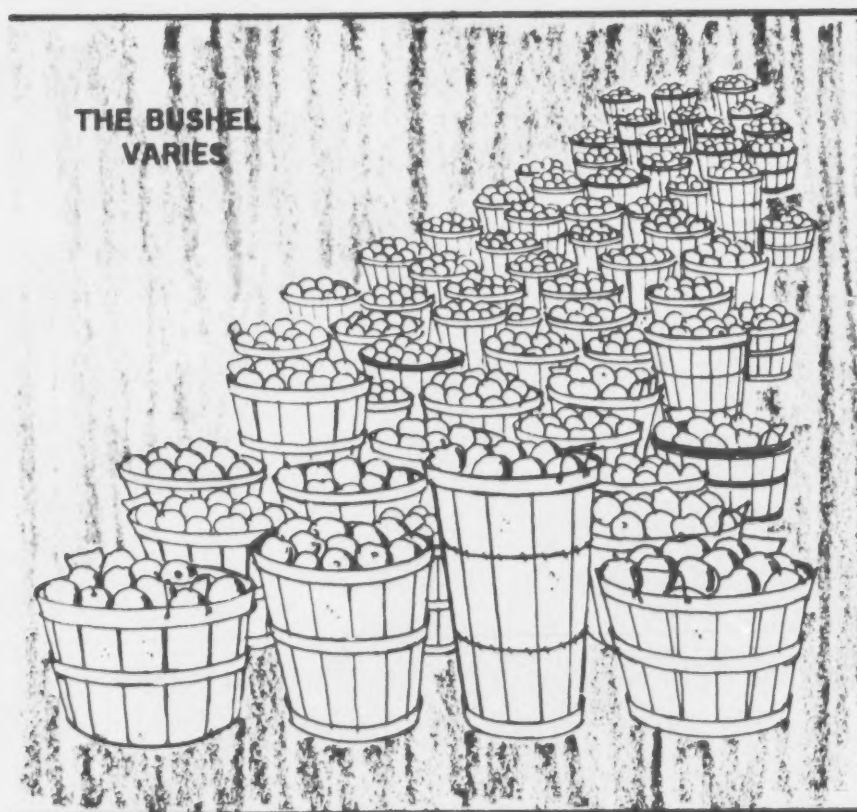




SIMPLIFIED METRIC EQUATION



CUSTOMARY U.S. EQUATION



GOING METRIC FOR STUDENTS -- NOTES AND COMMENTS

To the instructor:

This basic kit is designed to acquaint students with the metric system of measurement. It includes:

1. A 300 mm METRIC RULE
2. A METRIC/INCH CONVERTER
3. ALL YOU WILL NEED TO KNOW ABOUT METRIC. A basic information sheet
4. APPROXIMATE RELATIONSHIPS BETWEEN SI METRIC AND CUSTOMARY (ENGLISH) (WITHIN 10%). This is to get students to "think metric."
5. CONVERSION FROM THE CUSTOMARY TO THE METRIC SYSTEM FOR LENGTH
6. CONVERSION FROM THE CUSTOMARY TO THE METRIC SYSTEM FOR WEIGHT AND LIQUID MEASURE
7. COMPARING THE COMMONEST MEASUREMENT UNITS, WITH APPROXIMATE CONVERSIONS
8. THE MODERNIZED METRIC SYSTEM. A multicolored chart which provides accurate and up-to-date information concerning the international system of units.
9. PROGRAMED UNIT IN METRIC MEASUREMENT. To acquaint the students with the metric system, a programed unit is provided. It is recommended that the student place a blank piece of paper over the edge and try to answer each question. The learner can immediately check his answers to see if they are correct.

10. SELECTED METRIC REFERENCES. For those interested in further information on the SI metric system
- 11-18. ESTIMATING IN METRIC, MEASURE THE LENGTH OF THESE LINES IN MILLIMETRES, METRIC AREA MEASURE, METRIC VOLUME MEASURE, METRIC FLUID VOLUME MEASURE, METRIC TEMPERATURE MEASURE, MASS (WEIGHT), AND COMMON EXPRESSIONS IN METRICS. An activity or "learning" series. It is recommended that the instructor fill out each sheet before each lesson to make sure he has the correct answers. On the second page of ESTIMATING IN METRIC it is necessary for the instructor to obtain the common items that students must estimate in length. For example, a new pencil, paper clip, filmstrip container, postcard, etc., is needed. The matchbox should be a rectangular type, and the tumbler should be any glass or plastic type with tapered sides. If these last two items are not available, there is a transparency master for each of them in the next kit on GOING METRIC FOR CAREER TEACHERS. Answers are also provided for all activities (19-20.)

All You Will Need to Know About Metric

(For Your Everyday Life)

10

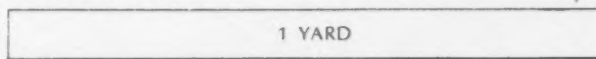
Metric is based on Decimal system

The metric system is simple to learn. For use in your everyday life you will need to know only ten units. You will also need to get used to a few new temperatures. Of course, there are other units which most persons will not need to learn. There are even some metric units with which you are already familiar: those for time and electricity are the same as you use now.

BASIC UNITS

- METER:** a little longer than a yard (about 1.1 yards)
LITER: a little larger than a quart (about 1.06 quarts)
GRAM: about the weight of a paper clip

(comparative sizes are shown)



25 DEGREES FAHRENHEIT



25 DEGREES CELSIUS

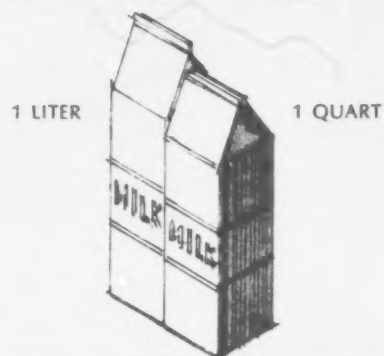
COMMON PREFIXES

(to be used with basic units)

- Milli:** one-thousandth (0.001)
Centi: one-hundredth (0.01)
Kilo: one-thousand times (1000)

For example:

- 1000 millimeters = 1 meter
 100 centimeters = 1 meter
 1000 meters = 1 kilometer



OTHER COMMONLY USED UNITS

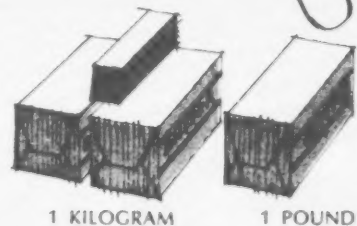
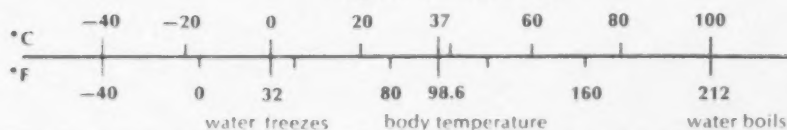
- | | | |
|--------------------|-------------|---|
| Millimeter: | 0.001 meter | diameter of paper clip wire |
| Centimeter: | 0.01 meter | width of a paper clip (about 0.4 inch) |
| Kilometer: | 1000 meters | somewhat further than 1/2 mile (about 0.6 mile) |
| Kilogram: | 1000 grams | a little more than 2 pounds (about 2.2 pounds) |
| Milliliter: | 0.001 liter | five of them make a teaspoon |

OTHER USEFUL UNITS

- Hectare:** about 2 1/2 acres
Tonne: about one ton

TEMPERATURE

degrees Celsius are used



For more information, write to: Metric Information Office, National Bureau of Standards
 Washington, D.C. 20234

Note: This chart may be reproduced.





APPROXIMATE RELATIONSHIPS BETWEEN SI METRIC AND CUSTOMARY (ENGLISH) (WITHIN 10%)

metre = yard = 3 ft.

1 mm 0.040 inch (1/25 or
half way between 1/16" and 1/32")

kilometre (km) = 5/8 mile

30 cm = 1 foot

litre = quart

10 mm = 0.4 inch = 3/8 inch

kilogram (kg) = 2 lbs.

25 mm = 1 inch

degree Celsius

Fahrenheit

0 C

freezing

32° F

21 C

room

70° F

37 C

body

98.6 F

100 C

boiling

212° F



CUSTOMARY SYSTEM

LENGTH

1 mile = 1760 yards

1 yard = 3 feet

1 foot = 12 inches

AREA

1 square mile = 640 acres

1 acre = 43 560 square feet

1 square yard = 9 square feet

1 square foot = 144 square inches

VOLUME

1 cubic yard = 27 cubic feet

1 cubic foot = 1728 cubic inches

METRIC SYSTEM

1 kilometre = 1000 metres

1 metre = 100 centimetres

1 centimetre = 10 millimetres

1 millimetre = 1000 micrometres

1 square kilometre = 100 hectares

1 hectare = 100 ares

1 are = 100 square metres

1 square metre = 100 square decimetres

1 square decimetre = 100 square centimetres

1 cubic metre = 1000 cubic decimetres

1 cubic decimetre = 1000 cubic centimetres

1 cubic centimetre = 1000 cubic millimetres

CONVERSION FACTORS

1 mile 1.6093 km

1 yard 0.9144 m

1 foot 0.3048 m

1 inch 2.54 cm

1 inch 25.4 mm

1 square mile

1 acre

1 square yard

1 square foot

1 square inch

2.5900 km²

0.4047 ha

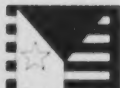
0.8361 m²9.290 dm²6.4516 cm²

1 cubic yard

1 cubic foot

1 cubic inch

0.8361 m²28.32 dm³16.39 cm³



WEIGHTS

CUSTOMARY SYSTEM

1 ton = 2000 pounds
1 pound = 16 ounces

METRIC SYSTEM

1 metric ton = 1000 kilograms
1 kilogram = 1000 grams
1 gram = 1000 milligrams

LIQUID MEASURES

1 gallon = 4 quarts = 231 cubic inches
1 quart = 2 pints
1 pint = 16 fluid ounces

1 kilolitre = 1000 litres
1 litre = 1000 millimetres
1 litre = 1 cubic decimetre (dm^3) = 1000 cubic centimetres (cm^3)

CONVERSION FACTORS

1 ton = 0.907 metric ton
1 lb. = 0.4536 kg
1 ounce = 28.35 g

1 gallon = 3.785 litre
1 quart = 0.946 litre
1 pint = 0.473 litre

1 fluid ounce = 29.57 cm^3
1 fluid ounce = 0.02957 litre

29.57 cm^3
0.02957 litre



COMPARING THE COMMONEST MEASUREMENT UNITS

Approximate conversions from Customary to metric and vice versa.

When you know:		You can find:	If you multiply by:
LENGTH	inches	millimetres	25.4 *
	feet	centimetres	30.48 *
	yards	metres	0.9
	miles	kilometres	1.6
	millimetres	inches	0.04
	centimetres	inches	0.4
	metres	yards	1.1
	kilometres	miles	0.6
AREA	square inches	square centimetres	6.5
	square feet	square metres	0.09
	square yards	square metres	0.8
	square miles	square kilometres	2.6
	acres	square hectometres (hectares)	0.4
	square centimetres	square inches	0.16
	square metres	square yards	1.2
	square kilometres	square miles	0.4
	square hectometres (hectares)	acres	2.5
MASS	ounces	grams	28
	pounds	kilograms	0.45
	short tons	megagrams (metric tons)	0.9
	grams	ounces	0.035
	kilograms	pounds	2.2
	megagrams (metric tons)	short tons	1.1
LIQUID VOLUME	ounces	millilitres	30
	pints	litres	0.47
	quarts	litres	0.95
	gallons	litres	3.8
	millilitres	ounces	0.034
	litres	pints	2.1
	litres	quarts	1.06
	litres	gallons	0.26
TEMPERATURE	degrees Fahrenheit	degrees Celsius	5/9 (after subtracting 32)
	degrees Celsius	degrees Fahrenheit	9/5 (then add 32)

* Exact conversions

THE MODERNIZED

metric system

The International System of Units-SI

is a modernized version of the metric system established by international agreement. It provides a logical and interconnected framework for all measurements in science, industry, and commerce. Officially abbreviated SI, the system is built upon a foundation of seven base units, plus two supplementary units, which appear on this chart along with their definitions. All other SI units are derived from these units. Multiples and sub-multiples are expressed in a decimal system. Use of metric weights and measures was legalized in the United States in 1866, and since 1893 the yard and pound have been defined in terms of the meter and the kilogram. The base units for time, electric current, amount of substance, and luminous intensity are the same in both the customary and metric systems.

meter-m

kilogram-kg

second-s

ampere-A

kelvin-K

mole-mol

candela-cd

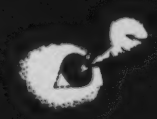
radian-rad

SEVEN BASE UNITS



TWO SUPPLEMENTARY UNITS

steradian-sr



and 19th centuries, the English system of weights and measures was spread to and established in many parts of the world, including the American colonies.

However, standards still differed to an extent undesirable for commerce among the 12 colonies. The need for greater uniformity led to clauses in the Articles of Confederation (ratified by the original colonies in 1781) and the Constitution of the United States (ratified in 1790) giving power to the Congress to fix uniform standards for weights and measures. Today, standards supplied to all the States by the National Bureau of Standards assure uniformity throughout the country.

The Metric System

The need for a single worldwide coordinated measurement system was recognized over 300 years ago. Gabriel Mouton, Vicar of St. Paul in Lyons, proposed in 1670 a comprehensive decimal measurement system based on the length of one minute of arc of a great circle of the earth. In 1671 Jean Picard, a French astronomer, proposed the length of a pendulum beating seconds as the unit of length. (Such a pendulum would have been fairly easily reproducible, thus facilitating the widespread distribution of uniform standards.) Other proposals were made, but over a century elapsed before any action was taken.

In 1790, in the midst of the French Revolution, the National Assembly of France requested the French Academy of Sciences to "deduce an invariable standard for all the measures and all the weights." The Commission appointed by the Academy created a system that was, at once, simple and scientific. The unit of length was to be a portion of the earth's circumference. Measures for ca-

capacity (volume) and mass (weight) were to be derived from the unit of length, thus relating the basic units of the system to each other and to nature. Furthermore, the larger and smaller versions of each unit were to be created by multiplying or dividing the basic units by 10 and its multiples. This feature provided a great convenience to users of the system, by eliminating the need for such calculations as dividing by 16 (to convert ounces to pounds) or by 12 (to convert inches to feet). Similar calculations in the metric system could be performed simply by shifting the decimal point. Thus the metric system is a "base-10" or "decimal" system.

The Commission assigned the name *metre* (which we now spell meter) to the unit of length. This name was derived from the Greek word *metron*, meaning "a measure." The physical standard representing the meter was to be constructed so that it would equal one ten-millionth of the distance from the north pole to the equator along the meridian of the earth running near Dunkirk in France and Barcelona in Spain.

The metric unit of mass, called the "gram," was defined as the mass of one cubic centimeter (a cube that is 1/100 of a meter on each side) of water at its temperature of maximum density. The cubic decimeter (a cube 1/10 of a meter on each side) was chosen as the unit of fluid capacity. This measure was given the name "liter."

Although the metric system was not accepted with enthusiasm at first, adoption by other nations occurred steadily after France made its use compulsory in 1840. The standardized character and decimal features of the metric system made it well suited to scientific and engineering work. Consequently, it is not surprising that the rapid spread of the

system coincided with an age of rapid technological development. In the United States, by Act of Congress in 1866, it was made "lawful throughout the United States of America to employ the weights and measures of the metric system in all contracts, dealings or court proceedings."

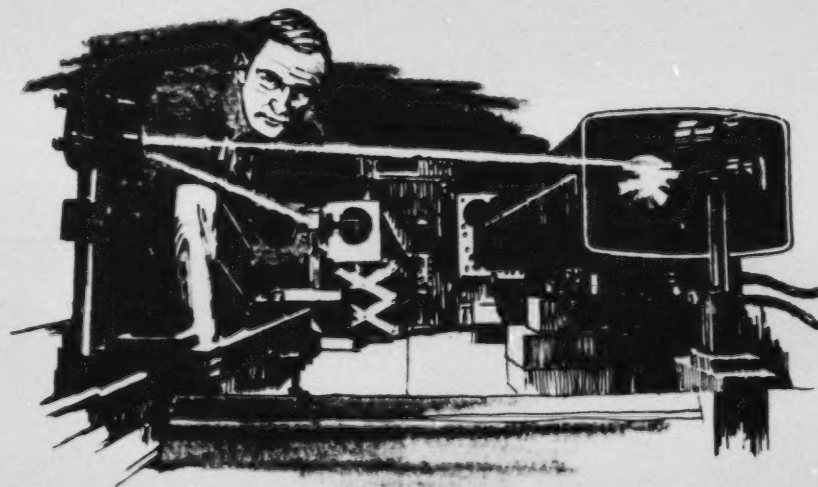
By the late 1860's, even better metric standards were needed to keep pace with scientific advances. In 1875, an international treaty, the "Treaty of the Meter," set up well-defined metric standards for length and mass, and established permanent machinery to recommend and adopt further refinements in the metric system. This treaty, known as the Metric Convention, was signed by 17 countries, including the United States.

As a result of the Treaty, metric standards were constructed and distributed to each nation that ratified the Convention. Since 1893, the internationally agreed-to metric standards have served as the fundamental weights and measures standards of the United States.

By 1900 a total of 35 nations—including the major nations of continental Europe and most of South America—had officially accepted the metric system. Today, with the exception of the United States and a few small countries, the entire world is using predominantly the metric system or is committed to such use. In 1971 the Secretary of Commerce, in transmitting to Congress the results of a 3-year study authorized by the Metric Study Act of 1968, recommended that the U.S. change to predominant use of the metric system through a coordinated national program. The Congress is now considering this recommendation.

The International Bureau of Weights and Measures located at Sevres, France, serves as a permanent secretariat for the Metric Convention, coordinating the exchange of information about the use and refinement of the metric system. As measurement science develops more precise and easily reproducible ways of defining the measurement units, the General Conference of Weights and Measures—the diplomatic organization made up of adherents to the Convention—meets periodically to ratify improvements in the system and the standards.

In 1960, the General Conference adopted an extensive revision and simplification of the system. The name *Le Système International d'Unités* (International System of Units), with the international abbreviation SI, was adopted for this modernized metric system. Further improvements in and additions to SI were made by the General Conference in 1964, 1968, and 1971.





Brief History of

MEASUREMENT SYSTEMS

with a Chart of the Modernized Metric System

"Weights and measures may be ranked among the necessities of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property; to every transaction of trade and commerce; to the labors of the husbandman; to the ingenuity of the artificer; to the studies of the philosopher; to the researches of the antiquarian, to the navigation of the mariner, and the marches of the soldier; to all the exchanges of peace, and all the operations of war. The knowledge of them, as in established use, is among the first elements of education, and is often learned by those who learn nothing else, not even to read and write. This knowledge is riveted in the memory by the habitual application of it to the employments of men throughout life."

JOHN QUINCY ADAMS
Report to the Congress, 1821



Weights and measures were among the earliest tools invented by man. Primitive societies needed rudimentary measures for many tasks: constructing dwellings of an appropriate size and shape, fashioning clothing, or bartering food or raw materials.

Man understandably turned first to parts of his body and his natural surroundings for measuring instruments. Early Babylonian and Egyptian records and the Bible indicate that length was first measured with the forearm, hand, or finger and that time was measured by the periods of the sun, moon, and other heavenly bodies. When it was necessary to compare the capacities of containers such as gourds or clay or metal vessels, they were filled with plant seeds which were then counted to measure the volumes. When means for weighing were invented, seeds and stones served as standards. For instance, the "carat," still used as a unit for gems, was derived from the carob seed.

As societies evolved, weights and measures became more complex. The invention of numbering systems and the science of mathematics made it possible to create whole systems of weights and measures suited to trade and commerce, land division, taxation, or scientific research. For these more sophisticated uses it was necessary not only to weigh

and measure more complex things—it was also necessary to do it accurately time after time and in different places. However, with limited international exchange of goods and communication of ideas, it is not surprising that different systems for the same purpose developed and became established in different parts of the world—even in different parts of a single continent.

The English System

The measurement system commonly used in the United States today is nearly the same as that brought by the colonists from England. These measures had their origins in a variety of cultures—Babylonian, Egyptian, Roman, Anglo-Saxon, and Norman French. The ancient "digit," "palm," "span," and "cubit" units evolved into the "inch," "foot," and "yard" through a complicated transformation not yet fully understood.

Roman contributions include the use of the number 12 as a base (our foot is divided into 12 inches) and words from which we derive many of our present weights and measures names. For example, the 12 divisions of the Roman "pes," or foot, were called *uncia*. Our words "inch" and "ounce" are both derived from that Latin word.

The "yard" as a measure of length can be traced back to the early Saxon kings. They wore a sash or girdle around the waist—that could be removed and used as a convenient measuring device. Thus the word "yard" comes from the Saxon word "gird" meaning the circumference of a person's waist.

Standardization of the various units and their combinations into a loosely related system of weights and measures sometimes occurred in fascinating ways. Tradition holds that King Henry I decreed that the yard should be the distance from the tip of his nose to the end of his thumb. The length of a furlong (or furrow-long) was established by early Tudor rulers as 220 yards. This led Queen Elizabeth I to declare, in the 16th century, that henceforth the traditional Roman mile of 5,000 feet would be replaced by one of 5,280 feet, making the mile exactly 8 furlongs and providing a convenient relationship between two previously ill-related measures.

Thus, through royal edicts, England by the 18th century had achieved a greater degree of standardization than the continental countries. The English units were well suited to commerce and trade because they had been developed and refined to meet commercial needs. Through colonization and dominance of world commerce during the 17th, 18th,

PROGRAMED UNIT IN METRIC MEASUREMENT

Complete the following sentences mentally as you look at the multi-color chart titled "The Modernized Metric System;" then uncover the answers provided in the right-hand column to see if you had the correct answers. (NOTE: The official spelling is metre and litre, but meter and liter are also acceptable as shown on the chart).

I. Seven Base Units

The International System of Units is a modernized version of the (1). The official abbreviation is (2). There are seven basic units of measurement. The unit of length is the (3). The abbreviation for metre is (4). The unit of mass (commonly known as weight) is the (5). The abbreviation is (6). The basic unit of time is unchanged. It is the (7). It is abbreviated (8). The unit of electric current is the (9). Its abbreviation or symbol is (10). The unit of temperature is the (11). The abbreviation for the kelvin is (12). However, for everyday use, the Celsius (old centigrade) scale is used. The unit for the amount of substance is the (13). Its abbreviation is (14). This unit is of primary use in science. The unit of luminous intensity is the (15). It has the abbreviation (16). Two supplementary units are the (17), for measuring plane angles (symbol = rad); and the (18), for measuring solid angles, (symbol = sr).

A N S W E R S

(1) metric system
(2) SI
(3) metre
(4) m
(5) kilogram
(6) kg
(7) second
(8) s
(9) ampere
(10) A
(11) kelvin
(12) K
(13) mole
(14) mol
(15) candela
(16) cd
(17) radian
(18) steradian

II. Multiples & Submultiples

Now, look at the lower left-hand part of the chart in black. Units smaller or larger than the metre (or any base unit) can be obtained by multiplying or dividing by ten, one hundred, one thousand, etc. Notice that the prefixes represent specific multiples and submultiples of ten when attached to the base units. For example, the prefix for a thousand is (1). Thus, when the metre is multiplied by 1000, it is called a (2). The prefix for one thousandth is (3). Thus, when the metre is divided by 1000, it is called a (4). The four major units of length are the millimetre which is one (5) of a metre; the centimetre which is one (6) of a metre; the kilometre which is (7) times the metre; and the metre which is the (8) unit.

The unit of liquid volume is the (9). A litre is equal to 1000 cubic millimetres. The very small unit of the litre is called the cubic millilitre. It is found by dividing the litre by (10). The four common lengths used for measurements are 1000 x the metre = (11). The base unit of length = (12). One hundredth of a metre = (13). One thousandth of a metre = (14).

A N S W E R S

(1) kilo
(2) kilometre
(3) milli
(4) millimetre
(5) thousandth
(6) hundredth
(7) thousand
(8) base
(9) litre
(10) 1000
(11) kilometre
(12) metre
(13) centimetre
(14) millimetre

III. Common Conversions

Now, look at the black section of the chart called "Common Conversions." In the customary English system of measurement, the lengths are in inches, feet, yards, and miles. The basic measurement of length for the new system is based on the (1). The metre is longer than the yard and measures 39.37 inches. The yard is shorter than the metre by (2) inches. The exact equivalent of the inch is 25.4 millimetres. The approximate equivalent of the inch is (3) millimetres. A kilometre is equal to (4) miles. A mile is equal to (5) kilometres. The liquid unit of measurement is called the (6). The litre is slightly larger than a (7). The unit of mass (weight) is the (8). The kilogram is approximately (9) pounds. A pound is equal to a (10) kilogram. NOTE: Three things to remember in the metric system: the metre unit of length is slightly longer than the yard; the litre (unit of liquid measure) is slightly more than the quart; the kilogram (unit of mass or weight) is slightly more than twice the weight of a pound. These are units the average person will use most.

A N S W E R S

(1)	metre
(2)	3.37
(3)	25
(4)	0.6
(5)	1.6
(6)	litre
(7)	quart
(8)	kilogram
(9)	2.2
(10)	.45

IV. Temperature

The fourth new unit that you must learn is the common metric unit of temperature known as the Celsius. (Temperature scales are covered in the green section of the chart.) The freezing point of water on the Celsius scale is at (1). Body temperature is (2). Water boils on the Celsius scale at (3). To change from degree fahrenheit to degree Celsius, first subtract 32 and then multiply by $5/9$. For example, if the fahrenheit temperature is 92° , subtract 32 which equals 60. Then multiply 60 by $5/9$. The Celsius temperature would be (4). If the fahrenheit temperature is 59° , the Celsius temperature would be (5).

To change from degree Celsius to degree fahrenheit, you would first multiply by $9/5$ and then add 32. For example, if the Celsius temperature is 20° , multiply this by $9/5$ which equals 36. Then add 32. The fahrenheit temperature would be (6). If the Celsius temperature is 30° , the fahrenheit temperature would be (7).

A N S W E R S

(1)	0°
(2)	37°
(3)	100°
(4)	33°
(5)	15°
(6)	68°
(7)	86°

CENTER FOR METRIC EDUCATION

Selected Metric References

General Metric Literature

ASTM METRIC PRACTICE GUIDE E380-72: American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103. 33 pp. & costs \$1.50 per copy, minimum order of \$3.00.

INTERNATIONAL SYSTEM OF UNITS (SI), NBS Special Publication 330, 1972 Edition: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. 42 pp. & costs \$.30 ea. Please order by No. C13.10:330/2.

PREPARE NOW FOR A METRIC FUTURE, Frank R. Donovan: Weybright & Talley, 750 Third Avenue, New York, NY 10009. 1971, 212 pp. & costs \$5.95 per copy.

history, metric fundamentals, and suggestions for implementation of the metric system

A METRIC AMERICA, U.S. Metric Study Interim Report: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. 1970, 192 pp. & costs \$2.25 ea. Please order by No. C13.10:345.

first of 13 reports by the U.S. Metric Study Committee; others available from the same source at a nominal cost

RULES FOR THE USE OF UNITS OF THE INTERNATIONAL SYSTEM OF UNITS: American National Standards Institute, 1430 Broadway, New York, NY 10018. 1969, 20 pp. & costs \$1.25. Please order by ISO Recommendation R1000.

General Audio/Visuals

THE METRIC SYSTEM: Coronet Films, Coronet Instructional Materials, 369 Erie Street, Chicago, IL 60610. 1 reel, viewing time - 11 minutes, 16 mm sound motion picture & costs \$65.00 for black and white, and \$130.00 for color.

history, basic fundamentals, comparison, and advantages of the metric system of measurement

METRIC WEIGHTS AND MEASURES: Library Filmstrip Center, 3033 Aloma, Wichita, Kansas 67211. 1 filmstrip and 1 cassette tape & costs \$20.00.

basic fundamentals of metric weights and measures

USOE SPONSORED PROJECT NO. V257006

GRANT NO. O EG-0-72-1868

Estimating in Metric

The common units of measurement in the metric system are millimetres (mm), centimetres (cm), and metres (m). On the typical metric rule, centimetres are numbered 1, 2, 3, etc. Between these numbered centimetre lines are ten (10) small divisions called millimetres (mm). For most industrial and technical work, however, only the millimetre (mm) and the metre (m) are used. Remember:

- the metre is slightly longer than a yard
- there are 1000 millimetres in a metre
- 300 millimetres are about equal to 1 foot

(NOTE: BEFORE ATTEMPTING THIS UNIT, YOU SHOULD CAREFULLY OBSERVE THE LENGTH OF A METRE STICK AND ITS SUBDIVISIONS.)

Estimate the number of metres to one decimal point; i.e., 3.2 m, for the following:

- | | | |
|---|-------|---|
| 1. Length of the desk | _____ | m |
| 2. Width of the door | _____ | m |
| 3. Height of the door | _____ | m |
| 4. Width of the room | _____ | m |
| 5. Length of the room | _____ | m |
| 6. Width of the window | _____ | m |
| 7. Height of the window | _____ | m |
| 8. Distance from the floor
to the bottom of the window | _____ | m |

Since the following items are smaller, estimate the dimensions in millimetres. (There are about 25 millimetres in an inch. Your instructor will show each of these items to you.)

- | | | |
|--|-------|----|
| 1. The length of an ordinary pencil | _____ | mm |
| 2. The length of a paper clip | _____ | mm |
| 3. The diameter of a filmstrip container | _____ | mm |
| 4. The height of the filmstrip container | _____ | mm |
| 5. The width of a postcard | _____ | mm |
| 6. The length of a postcard | _____ | mm |
| 7. The thickness of the matchbox | _____ | mm |
| 8. The width of the matchbox | _____ | mm |
| 9. The length of the matchbox | _____ | mm |
| 10. The large diameter of the tumbler | _____ | mm |
| 11. The small diameter of the tumbler | _____ | mm |
| 12. The height of the tumbler | _____ | mm |

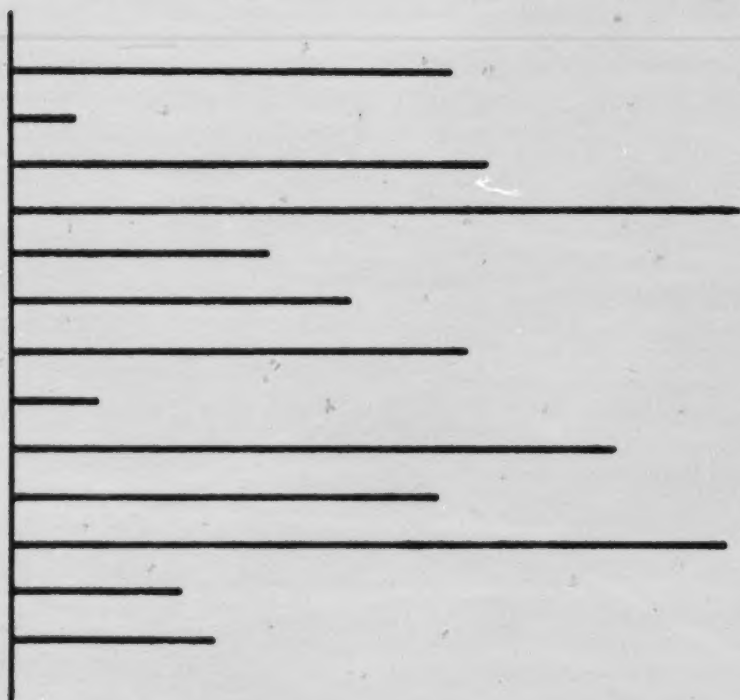
MEASURE THE LENGTH OF THESE LINES IN MILLIMETRES

The list of phrases (A-M) give the dimensions of common lines. Use your metric rule to check the length of each line to determine what item it represents. Place the letter of the item and the length of the line in the appropriate spaces.

- A. width of a picture slide (50 mm)
- B. width of a business envelope (105 mm)
- C. height of an 8-cent postage stamp (25 mm)
- D. diameter of a button (10 mm)
- E. diameter of a fifty-cent piece (30 mm)
- F. width of a dollar bill (65 mm)
- G. width of a hacksaw blade (13 mm)
- H. diameter of a paint can (107 mm)
- I. diameter of a cup (67 mm)
- J. width of an electrical switch plate (70 mm)
- K. thickness of a dry 2x4 (lumber) (38 mm)
- L. width of a dry 2x4 (lumber) (89 mm)
- M. width of a cassette recording tape (63 mm)

(Measure from outside of vertical line.)

Lines



Item Letter	Length of Line
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm
	mm

The width of this paper is ____mm.

The length of this paper is ____mm.

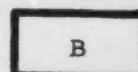
METRIC AREA MEASURE

Areas are measured in squares. To find area, you must multiply the two dimensions--length and width. Very small areas are measured in square millimetres or square centimetres. Large areas are measured in square metres.

1. A is ____ square centimetre (cm^2).



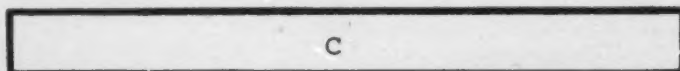
2. There are ____ square centimetres (cm^2) in B.



3. In question 2, B would equal ____ mm^2 .

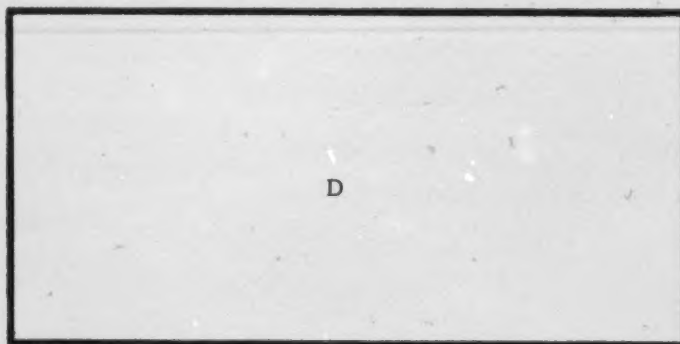
4. There are ____ mm^2 in C below.

5. C below is equal to ____ m^2 .



6. D below contains ____ mm^2 .

7. D below is equal to ____ cm^2 .



8. A floor that is 24 metres long and 12 metres wide contains an area of ____ square metres (m^2).

Use your metric converter to complete the following:

1. 2 square inches equal ____ cm^2 .
2. 20 square centimetres equal ____ square inches.
3. 1 square metre equals ____ square yards.
4. 3 square yards equal ____ m^2 .

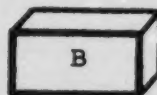
METRIC VOLUME MEASURE

Volume is measured in cubes. To find volume you must multiply the three dimensions--length, width, and height. A cube 1 m (39.37") x 1 m x 1 m equals 1 cubic metre (m^3). A cubic metre is larger than a cubic yard (about 6 cubic metres equals 8 cubic yards). Cubic measurement is used for sand, gravel, cement, and similar materials. Smaller volumes are measured in cubic centimetres (cm^3) and very small volumes in cubic millimetres (mm^3).

1. There is ____ cubic centimetre in A.



2. There are ____ cubic centimetres (cm^3) in B.



3. Make an isometric drawing of 3 cubic centimetres on the line below.

4. The drawing above (Question 3) contains ____ cubic millimetres (mm^3).
5. Complete the following in cubic metres (m^3):

<u>Length</u>	<u>Width</u>	<u>Height</u>	<u>m^3</u>
2	3	6	_____
3	8	5	_____
5	10	3	_____
4	7	6	_____

6. A match box that is 4 cm long, 3 cm wide, and 1 cm high contains ____ cubic millimetres (mm^3).

Use your metric converter to find the following:

- 1 cubic metre equals ____ cubic yards.
- 1 cubic yard equals ____ cubic metres.
- A home excavation is 4 metres wide, 8 metres long, and 2 metres high. How many cubic yards of materials must be removed?

- 15 cubic yards equals ____ cubic metres.

Metric Fluid Volume Measure

The basic unit of volume for liquid measure is the litre. It is equal to one cubic decimetre, or 1000 cubic centimetres. The litre is slightly larger than a quart (about 6 percent larger). The litre--unit of volume--is directly related to the metric capacity and weight. A litre has a volume of 1000 cubic centimetres (one cubic decimetre) and, if filled with water, will weigh 1000 grams (1 kilogram).

Complete the following:

1. A cubic decimetre is equal to the unit of volume known as the ____.
2. There are ____ litres in a cubic metre.
3. A tank of gasoline that is 2 decimetres high, 2 decimetres wide, and 2 decimetres deep will contain ____ litres.
4. If you poured a litre of paint into a quart can, it would overflow. Yes ____ No ____
5. If you poured two pint cans of oil into a litre container, the oil would overflow. Yes ____ No ____
6. If the water in a container weighed 2500 grams, it would contain ____ litres of fluid.
7. A box that contained 8000 cubic centimetres has the capacity of ____ litres.
8. A case that has the inside dimensions of 20 cm high by 70 cm long by 40 cm wide has the capacity of ____ litres.

2 pints	=	1 quart
4 U.S. quarts	=	1 U.S. gallon
10 litres	=	1 cubic metre

Use your metric converter to answer the following:

1. One U.S. gallon equals ____ litres.
2. Six quarts equals ____ litres
3. Ten litres equals ____ U.S. gallons
4. An 18-gallon gas tank will hold ____ litres of gas.
5. If one U.S. gallon of liquid is poured into a one cubic metre tank that is already half full, it will then be holding ____ litres.
6. The cubic metre tank, in the above question, would be holding ____ U.S. gallons.

METRIC TEMPERATURE MEASURE

The basic metric unit of temperature measurement is the kelvin (K). This unit is used only in scientific applications where measures of absolute zero are needed. For most purposes, the Celsius scale (replacing the old centigrade scale) is used, which is derived from the kelvin. The relationships between Fahrenheit and Celsius are as follows:

- Water boils at 100°C and 212°F
- Water freezes at 0°C and 32°F
- Body temperature is 37°C and 98.6°F

Conversions between Celsius and Fahrenheit can be made as follows:

$$\text{Temp. F} = 1.8 (\text{Temp. C}) + 32$$

$$\text{Temp. C} = (\text{Temp. F} - 32) / 1.8$$

or

$$\text{Temp. F} = 9/5 (\text{Temp. C}) + 32$$

$$\text{Temp. C} = (\text{Temp. F} - 32) 5/9$$

Do the following conversion problems by using either set of the above formulas:

1. $90^{\circ}\text{C} = \underline{\hspace{2cm}}^{\circ}\text{F}.$

2. $25^{\circ}\text{F} = \underline{\hspace{2cm}}^{\circ}\text{C}.$

Use your conversion slide rule for the following problems:

3. $180^{\circ}\text{C} = \underline{\hspace{2cm}}^{\circ}\text{F}.$

4. $350^{\circ}\text{F} = \underline{\hspace{2cm}}^{\circ}\text{C}.$

5. $600^{\circ}\text{F} = \underline{\hspace{2cm}}^{\circ}\text{C}.$

Mass (Weight)

The basic unit of mass (weight) is the kilogram (kg).

Weight and mass are about the same on earth. A kilogram is equal to about 2.2 pounds at sea level. There are 1000 grams in a kilogram. For larger units of weight the metric ton is used, which is equal to 1000 kilograms or 1,000,000 grams.

Mass (weight): 1000 milligrams (mg) = 1 gram (g)
 1000 g = 1 kilogram (kg)
 1000 kg = 1 metric ton (t)

Complete the following:

1. 1000 milligrams added to 1 kilogram would equal ____ milligrams.
2. 300 grams added to 1 kilogram would equal ____ milligrams.
3. 4200 kilograms equals ____ metric tons.
4. Convert 120 mg to ____ g.
5. Change 2525 g to ____ kg.
6. Producer A charges \$42.00 per metric ton for cement while producer B charges 5¢ per kilogram. Which is cheaper, A or B?

7. The following dry ingredients are to be mixed into a cake batter. What is their total weight in kilograms? ____ kg
200 grams butter
275 grams sugar
50 grams of chocolate
250 grams of self-rising flour

Use your metric converter to complete the following:

1. 4 pounds equals ____ kg.
2. 3 kilograms equal ____ lbs.
3. 2 pounds plus 6 pounds equals ____ kg.
4. 2 metric tons equals ____ tons.
5. 6 tons equals ____ tons.
6. If a truck driver has to haul 22,000 pounds of coal with a truck that has the capacity of 2 metric tons, how many loads does he take? ____ loads

Common Expressions in Metrics

Below you will find a list of common expressions that contain various customary units of measure. See if you can convert those customary units that are underlined into equivalent metric units in the spaces provided after the phrases.

1. An ounce of practice is worth a pound of preaching. _____
2. Give them an inch, and they will take a mile. _____
3. It is better to buy a quart of milk by the penny than keep a cow. _____
4. An ounce of prevention is worth a pound of cure. _____
5. He's all wool and a yard wide. _____
6. A miss is as good as a mile. _____
7. Measure yourself by your own foot. _____
8. My cup runneth over _____
9. I wouldn't touch that with a ten-foot pole. _____
10. To put a quart into a pint-pot. _____
11. The texan was wearing a ten-gallon hat. _____
12. Don't hide your light under a bushel basket. _____
13. Five foot-two, eyes of blue. _____

Answer Sheet

Metric Length of Lines

F	65 mm
D	10 mm
J	70 mm
H	107 mm
K	38 mm
A	50 mm
I	67 mm
G	13 mm
L	89 mm
M	63 mm
B	105 mm
C	25 mm
L	30 mm

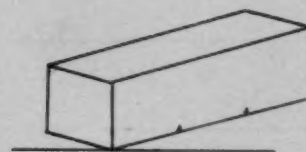
Metric Area Measure

- 1
 - 2
 - 200
 - 1 000
 - 0.001
 - 5 000
 - 50
 - 288
-

- 13
- 3.1
- 1.2
- 2.5

Metric Volume Measure

- 1
- 2
-



- 3 000
- 36 m³
- 120 m³
- 150 m³
- 168 m³

- 12 000
-

- 1.3
- 0.76
- 82 cubic yards
- 11.5

Liquid Measure

1. litre
 2. 10
 3. 8 litres
 4. yes
 5. no
 6. $2\frac{1}{2}$
 7. .8
 8. 56
-

1. 3.8
2. 5.7
3. 2.6
4. 68
5. 8.8
6. 2.3

Temperature

1. 194°F
2. -3.8°C
3. 356°F
4. 177°C
5. 316°C

Mass (weight)

1. 1,001,000
2. 1,300,000
3. 4.2
4. .12
5. 2.525

Mass (weight) continued

6. A
 7. 9.75
-
1. 1.8 kg
 2. 6.6 lbs.
 3. 3.6 kg
 4. 2.2 tons
 5. 5.4 metric tons
 6. 5

Common Expressions

1. 28.3 grams
2. 25 mm
3. 1.1 litres
4. .45 kg
5. 91.5 cm
6. 1.6 km
7. 30.5 cm
8. .27 litre
9. 304.8 cm
10. .55 litre
11. 37.8 litres
12. 35.2 litres
13. 157.4 cm

GOING METRIC IN DRAFTING -- NOTES AND COMMENTS

1. MEASURING WITH A RULE. The rule is graduated in millimetres, with each centimetre numbered. The measurements at 12 mm, 28 mm, and 42 mm are used to acquaint the student with linear measure, because in drafting linear measure is most important.
2. DIRECT READING CONVERSION SCALE. This is an example of a 1 to 1 unit conversion showing a comparison between inches in sixteenths and inches in tenths to millimetres. This is an example of a direct conversion to metric measure. Direct conversion is important when a design in the customary system has to be expressed in metric terms.
3. ARCHITECTS SCALE COMPARISON. (1 and 1:10) All scales in the architects series are drawn with a 2:1 enlargement. The important thing to remember in using a metric scale is that there is not a 1 to 1 unit conversion from a metric to a customary scale, if common metric ratios are to be maintained. On this basis the comparison is not a linear one, but a usage one. As an example, if a 1" = 1' scale was needed for a customary drawing, a 1 mm = 10 mm metric scale would probably be used for a similar metric drawing even though this is not a pure 1 to 1 conversion.
4. ARCHITECTS SCALE COMPARISON. (1/2 and 1:25, 1:1250, 1:2500) It must be further noted that, when using metric scales, the user shouldn't be concerned with a comparable customary measure

but only with the metric measure. For a unit comparison, a conversion chart should be used. The 1:25 scale is a good ratio comparison to the $1/2" = 1'$ customary. The scales from 1:1250 up to 1:50000 are used in map making. Remember that a ratio is a proportional relationship; i.e., the number of times the first digit contains the second. For example, the ratio 1:10 means 1 mm contains 10 mm . The chart on the following page will aid in selecting the proper metric scale for a given problem.

RATIO COMPARISON CHART
METRIC AND CUSTOMARY SCALES

Metric Scale mm/mm	Customary Scale inch/inch	Use
1:1	12:12	full size
1:2	6:12	half size
1:5	3:12	quarter size, details*
1:10	1:12	1" = 1"*
1:20	3/4:12	3/4" = 1'* construction details
1:25	1/2:12	1/2" = 1'* detail sections
1:50	1/4:12	1/4" = 1'* plans, elevations, sections
1:100	1/8:12	1/8" = 1'* plot plans
1:200	1/16:12	1/16" = 1'* plot plans
1:500	1/32:12	1/32" = 1'* site plans
1:1250	1:1267	50" = 1 mile*
1:2500	1:2534	25" = 1 mile* site maps
1:10000	1:10560	6" = 1 mile*
1:50000	1:63360	1" = 1 mile* location maps

*approx. equiv.

5. ARCHITECTS SCALE COMPARISON. ($1/8$ and 1:100, $1/4$ and 1:50)

Differences between scales can be shown. In metric measure everything is based on tenths, so each scale metric unit doesn't have to be converted to twelfths, as when using customary scales.

A further comparison between metric scales can then be shown, such as comparing the 1:50 and 1:100 metric ratios. (One is twice the size of the other). In this set, the metric scales should be emphasized and the customary scales de-emphasized.

6. ARCHITECTS SCALE COMPARISON. ($3/8$ and 1:25, $3/4$ and 1:20)

These scales are used for plans, elevations, and sections.

7. ARCHITECTS SCALE COMPARISON. ($3/32$ and 1:125, $3/16$ and 1:50)

For general drafting, the 1:50 is preferred.

8. ARCHITECTS SCALE COMPARISON. ($1\ 1/2$ and 1:10, 3 and 1:5)

The 1:5 scale is an approximation of quarter size and is preferred for detail drawings.

9. PREFERRED METRIC SCALES. In the ISO system the familiar quarter-

scale and eighth-scale are not preferred. The preferred ratios

are shown and should be used if possible. It should be

emphasized, however, that these are only preferred, not required.

10. DECIMAL SCALE COMPARISON. (10 and 1:10, 20 and 1:20) All scales

in the decimal series are drawn with a 2:1 enlargement. This

comparison is based on preferred metric ratios, rather than

common metric ratios, such as used in the architects scale

comparison. The variety of scales used is smaller when using

only preferred ratios, as is shown in the following table:

<u>Decimal Scale</u>	<u>Metric Scale</u>
10	1:10
20	1:20
30	1:50
40	1:50
50	1:50
60	1:50

11. DECIMAL SCALE COMPARISON. (30 and 1:50, 40 and 1:50) It should be further emphasized by this comparison that when selecting a metric scale the last concern should be a 1 to 1 unit conversion, with the first concern being usage of the metric scale chosen.
12. DECIMAL SCALE COMPARISON. (50 and 1:50, 60 and 1:50) The metric scale series, as can be seen, eliminates the customary divisions into architects, engineers, and decimal scale grouping. The metric series encompasses them all.
13. ENLARGEMENT AND REDUCTION SCALES. These are preferred scales for enlarging or reducing a drawing. Note that these are the same as the preferred metric scales.
14. DECIMALS OF AN INCH TO MILLIMETRES. When converting inches to millimetres, if three decimal places are maintained, such as 0.001 in. = 0.025 mm, the millimetre conversion is more precise because 1 in. = 25.4 mm. So, a general rule for this type of conversion could be to round the mm value to one less place than the inch value. However, 0.1 in. = 2.5 mm would give a better indication of the conversion than 0.1 in. = 2 mm.

15. OVERLAY. The overlay is used to show the student this concept.
16. DECIMALS OF AN INCH TO MILLIMETRES - (ROUNDED VALUES). These are the rounded values of the previous transparency.
17. FRACTIONS OF AN INCH TO MILLIMETRES. Charts 17, 18, and 19 are a convenience when discussing customary/metric conversions with students.
18. INCHES TO MILLIMETRES. (See notes for 17.)
19. MILLIMETRES TO INCHES. (See notes for 17.)
20. ROUND-OFF RULES (TOLERANCING). These are general rules for rounding off the converted millimetre and inch values for tolerancing. It is recommended that all conversions be rounded inward so the millimetre value will be within the design tolerance. The converted tolerance limits will then never exceed the original limits. The practice of rounding off the converted millimetre limits within the design tolerance is applicable only to limit dimensioning.
21. METRIC LINEAR SIZES. (GENERAL) This chart shows preferred sizes and would be suitable for general design in engineering. It means, in effect, that the design of components should reflect these dimensioned standards. For example, a component measuring 20 x 110 x 280 would be preferred to one measuring 21 x 115 x 270. These preferred figures are more convenient to work with and are more logical.

22. PREFERRED METRIC SIZES FOR ENGINEERING. (SPECIFIC) This chart would be best suited to specific design in metric linear sizes. Note that there are first, second, and third choices and that the values in the column for each choice increase by powers of ten. Examples: first choice increases from 1 to 10 to 100, or the third choice increases from 1.3 to 13 to 130.
23. OVERLAY FOR 22. no comment
24. OVERLAY FOR 22. no comment
25. ISO - A SIZE PAPER. (See comparison chart in 26.)
26. COMPARISON CHART - A SIZE PAPER. A further comparison between customary and metric sized paper is:

<u>Customary</u>		<u>Inch Size</u>		<u>Metric</u>
A	=	8½ x 11	=	A4
B	=	11 x 17	=	A3
C	=	17 x 22	=	A2
D	=	22 x 34	=	A1
E	=	34 x 44	=	A0

27. ORTHOGRAPHIC PROJECTION COMPARISON. First-angle projection isn't a metric method of drawing but a consequence of international standards. One of the main reasons metrication is taking place in the United States is to facilitate communication on the international level. Since many European countries draw in first-angle projection; it is important for the students to at least get a basic exposure to first-angle projection. The difference between first and third angle projection is that in first-angle the object as viewed is projected onto the drawing surface,

while in third-angle the object is drawn as viewed. A careful study of this transparency will clarify this idea. A metric drawing should specify first or third-angle projection, as indicated on the transparency.

28-31. OVERLAYS FOR 27. no comment

32. ABBREVIATIONS. Note some of the changes, such as the symbols used for diameter and square.

33. GEOMETRIC CHARACTERISTIC SYMBOLS. Note differences between ANSI (American National Standards Institute) and ISO (metric).

34. DUAL DIMENSIONING. Dual dimensioning is just one of the several ways a drawing can be expressed in both metric and customary terms. The type of drawing and situation determine the dimensioning method used. The secondary form will always be bracketed.

35. MASTER DIMENSIONING (WITH CUSTOMARY READOUT CHART).

The object is dimensioned in millimetres with a millimetre to inch conversion in the upper left-hand corner.

36. MASTER UNIDIMENSIONING. The master drawing is done without the dimensions so either the metric or customary values can be placed on the drawing. In the case of the transparency master, the overlays can serve this purpose.

37. OVERLAY FOR 36. no comment

38. OVERLAY FOR 36. no comment

39. IDENTIFICATION LETTER DIMENSIONING. Letters are placed on the drawing in lieu of dimensions. A conversion chart is placed in

the upper left-hand corner of the drawing. There could be a conflict between the letter designating a dimension and a geometrically toleranced surface so the letters P = Primary, S = Secondary, and T = Tertiary are reserved for geometrically toleranced surfaces only.

40. METRIC GRID. Each small square equals two millimetres. This grid can be used to check metric sizes by placing the transparency over a drawing and assigning a metric value to each square. A 1:1 ratio would mean each square would equal 2 mm , while a 1:10 ratio would mean that each square would equal 20 mm .
41. METRIC DRAWING--WOODWORKING (VENEERED BOX). This is a typical woodworking drawing with the millimetre as the basic unit. The conversion chart is placed on the drawing for the convenience of the reader to acquaint him with the metric customary size equivalents.
42. METRIC DRAWING--METALWORKING (TOOLMAKER'S CLAMP). This typical toolmaker's clamp can be easily made of standard materials available in the average school lab. The only extra equipment necessary is a metric tap and die set for the more common metric threads.
43. COMPARISON OF COMMON THREAD SIZES. The ISO metric thread (coarse series) compared with the unified national, UNC coarse series, (also known as the ISO inch series). Note

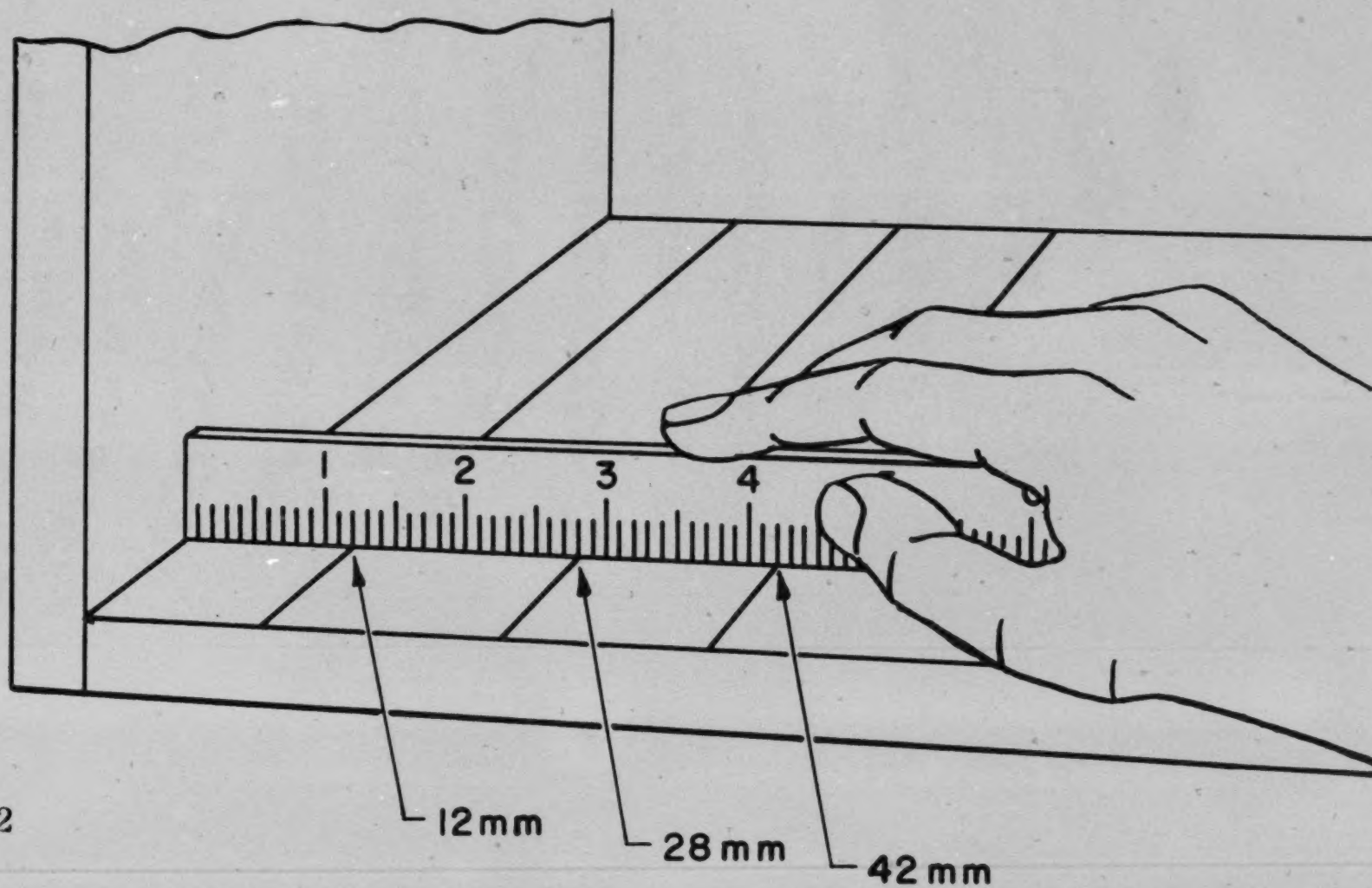
that in the metric series the diameter is shown in millimetres, the pitch (which is the distance from the top of one thread to the top of the next) is shown in millimetres and the tolerance is also given when necessary. Remember that in the metric threads the pitch is given, while in the unified national series the number of threads per inch is given. Even though these two threads appear very close in size and number of threads, they are not interchangeable because the metric thread has almost 17 threads per inch, while the unified national has 16 threads per inch.

44. ISO METRIC THREAD--COARSE SERIES. The 12 sizes that are in tinted form represent approximately 90% of the metric threads used in average manufacturing. Note how simple it is to arrive at the correct tapping drill size. Merely subtract the pitch from the diameter to secure the tap drill in millimetres. For example, if the pitch is 4, then the tap drill size will be 3.3 millimetres.
45. ISO METRIC THREAD--FINE SERIES. This series is rarely used except for precision measuring instruments. ISO metric threads in the fine series are difficult to purchase since they are not in common use.
46. ISO METRIC THREAD FORM. This illustrates details of the internal and external threads and how the dimensions are determined.
47. THREAD FORM -- ISO METRIC AND ISO INCH SERIES. Note that the

thread form is identical for the ISO metric and ISO inch (commonly known as the unified national thread form). However, the threads are not interchangeable.

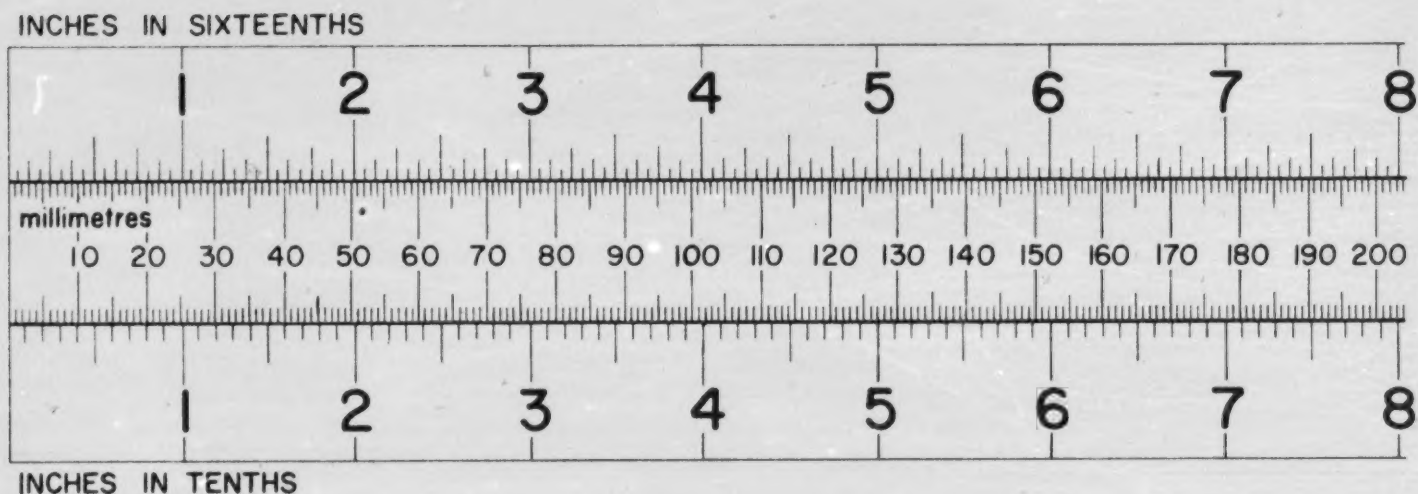
48. PARTS OF A METRIC MICROMETER. This is a standard reading metric micrometer. Each of the lines above the datum line represents a full millimetre. Each line below represents a half millimetre. There are 50 divisions around the thimble, each representing 0.01 millimetre.
49. READING A METRIC MICROMETER. Note that 5 full lines above the datum line are visible. This represents 5.00 millimetres. A half line is visible below the datum line and this represents 0.50 millimetre. Each division on the thimble represents 0.01 mm. There are 28 divisions showing on the thimble representing 0.28 millimetre so that the final reading is 5.00 plus 0.50 plus 0.28 which equals 5.78 mm.
50. CUSTOMARY-METRIC VERNIER CALIPER. Note that this is a combination of customary/metric vernier caliper.
51. METRIC VERNIER CALIPER. There are several types of vernier scales used on the metric vernier calipers. The main beam of the caliper is divided into numbered lines each representing centimetres, longer division lines representing millimetres, and short division lines representing half millimetres. The vernier is divided into 25 equal divisions. Each small

division represents 0.02 millimetre. To read this correctly, note that the zero line on the vernier scale is three small divisions past 4. The 4 represents 40 millimetres. The next largest line represents 1 millimetre for a total of 41 millimetres. The small line on the beam represents 0.50 millimetre. Note that the 9 line on the vernier lines up directly with the line on the beam. Since each of these lines represent 0.02 mm, you must multiply by 9 so that the resultant is 0.18. The reading equals 41.00 mm plus 0.50 mm plus 0.18 mm for a total reading of 41.68 mm .





DIRECT READING CONVERSION SCALE



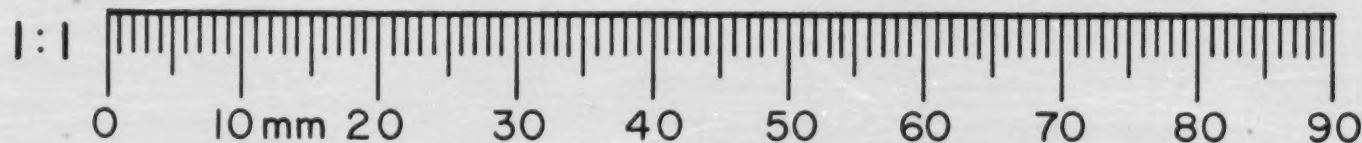


ARCHITECTS SCALE COMPARISON

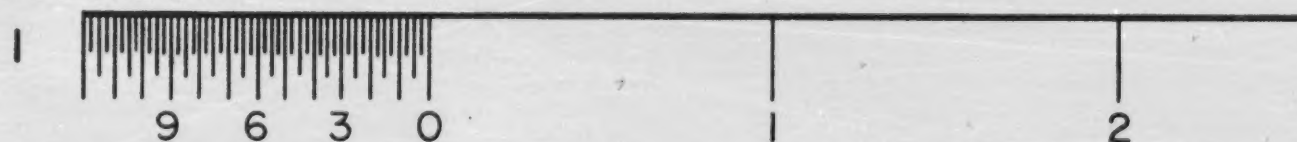
CUSTOMARY



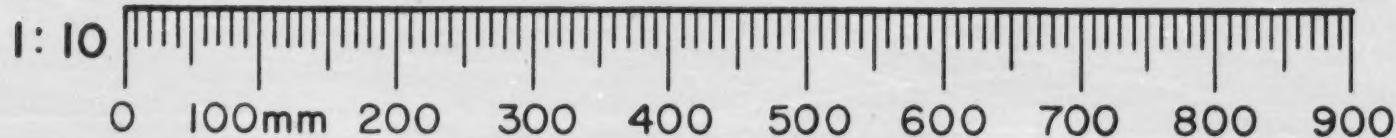
METRIC



CUSTOMARY



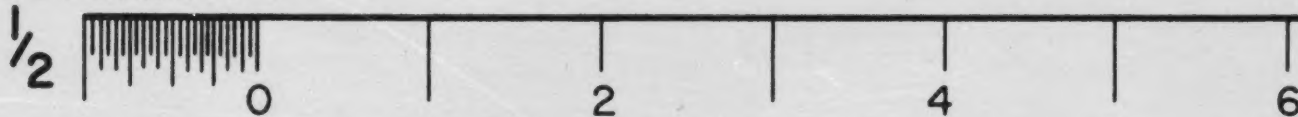
METRIC



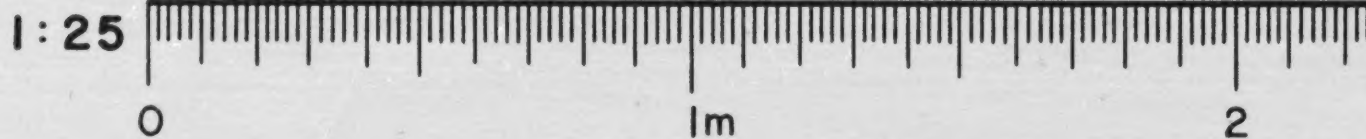


ARCHITECTS SCALE COMPARISON

CUSTOMARY



METRIC



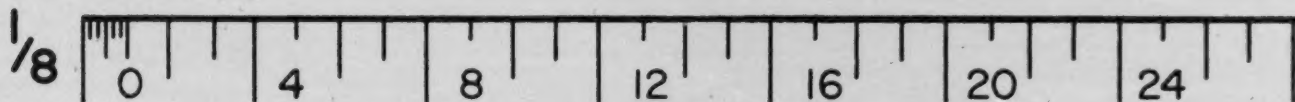
**ADDITIONAL
COMMON
METRIC
SCALES**



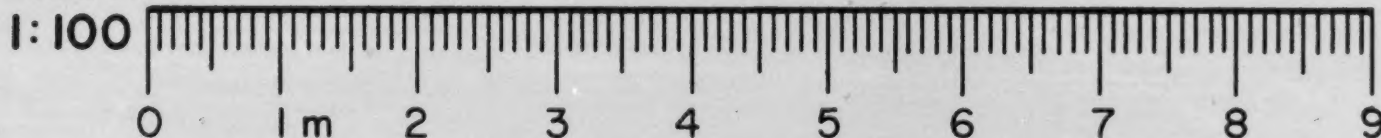


ARCHITECTS SCALE COMPARISON

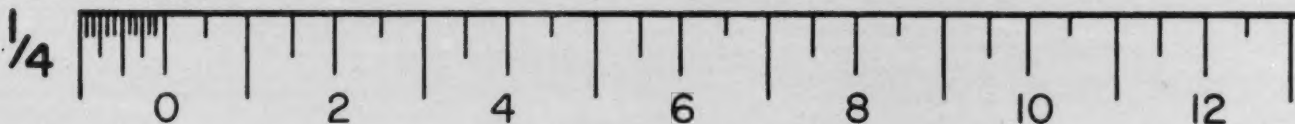
CUSTOMARY



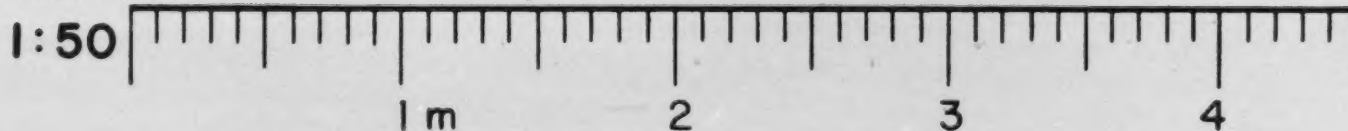
METRIC



CUSTOMARY



METRIC

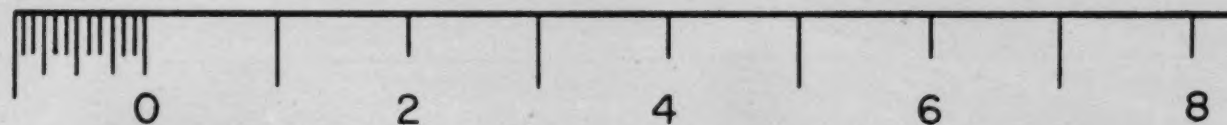




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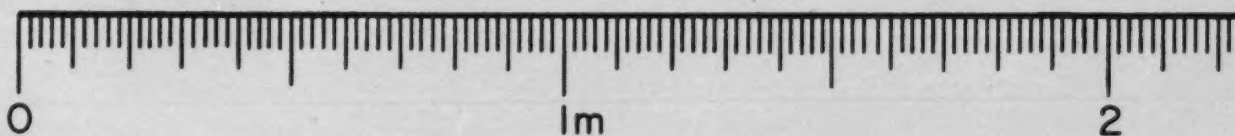
CUSTOMARY

$\frac{3}{8}$



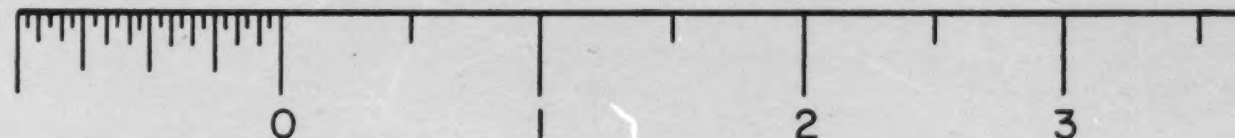
METRIC

1 : 25



CUSTOMARY

$\frac{3}{4}$



METRIC

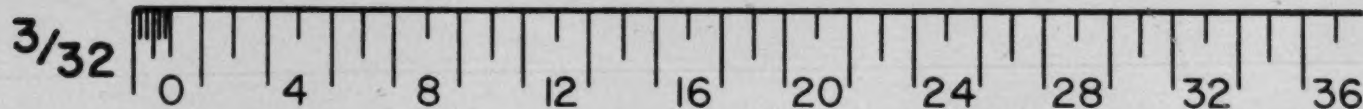
1 : 20





ARCHITECTS SCALE COMPARISON

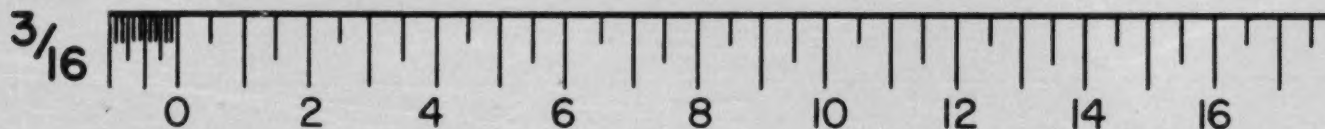
CUSTOMARY



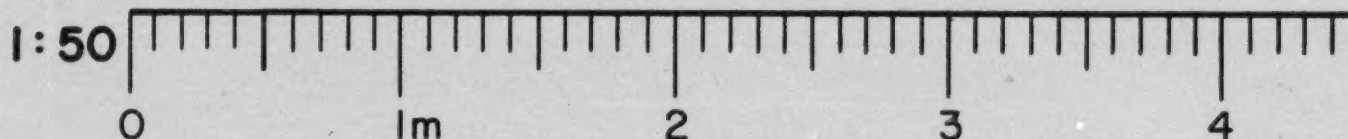
METRIC

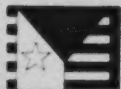


CUSTOMARY



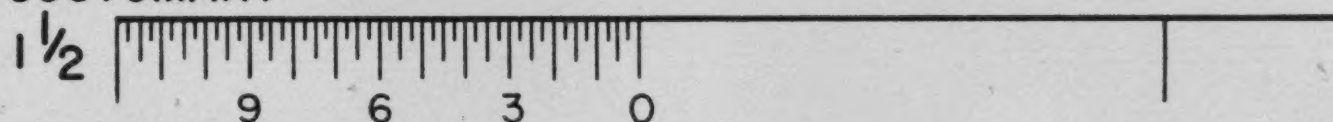
METRIC



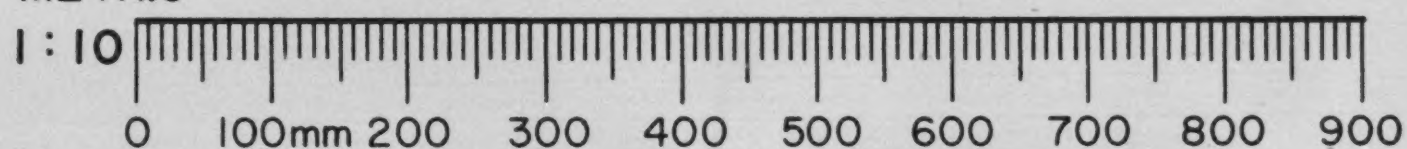


ARCHITECTS SCALE COMPARISON

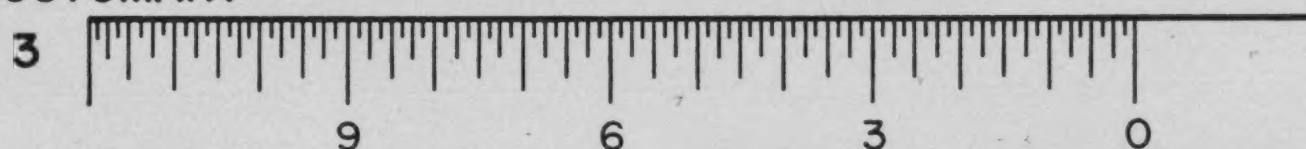
CUSTOMARY



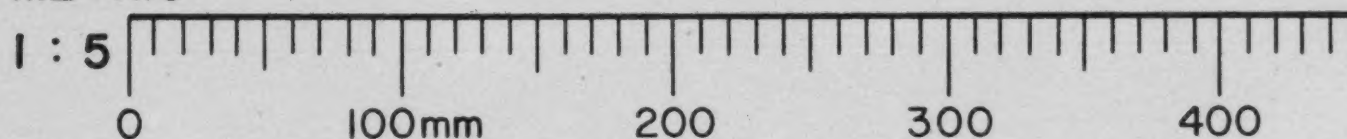
METRIC



CUSTOMARY



METRIC



PREFERRED METRIC SCALES

1:1

1:2

1:5

1:10

1:20

1:50

1:1250

1:2500



DECIMAL SCALE COMPARISON

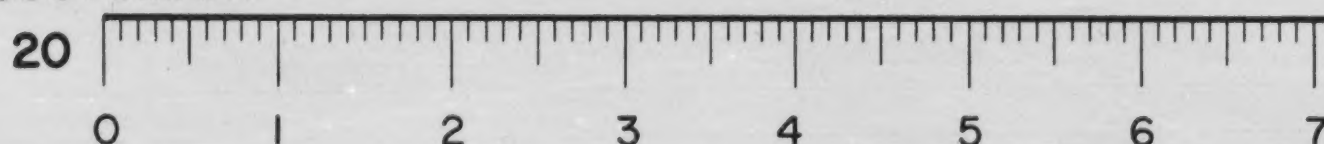
CUSTOMARY



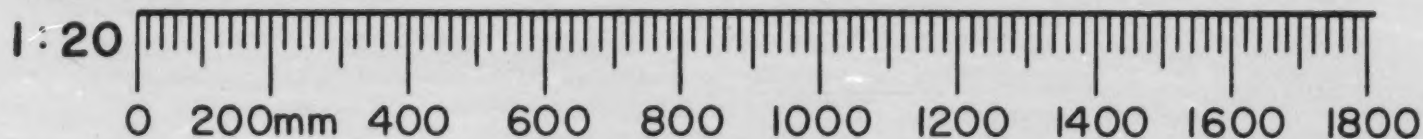
METRIC



CUSTOMARY



METRIC



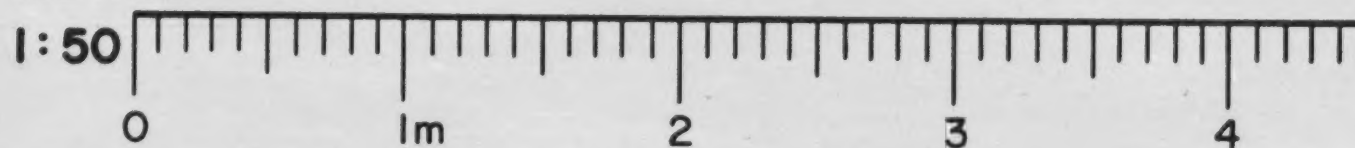


DECIMAL SCALE COMPARISON

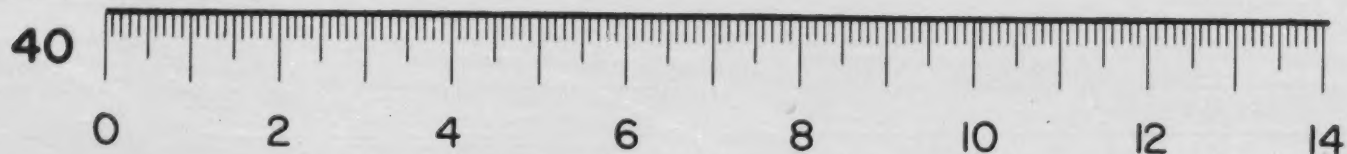
CUSTOMARY



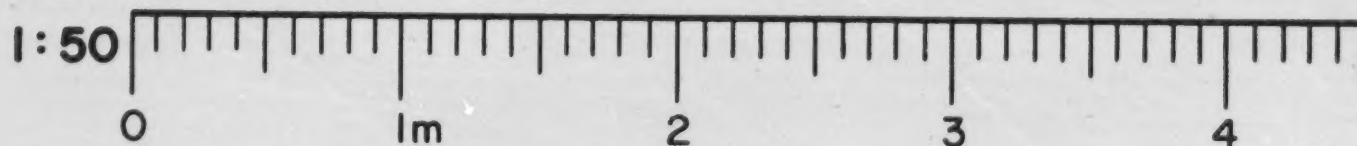
METRIC



CUSTOMARY



METRIC

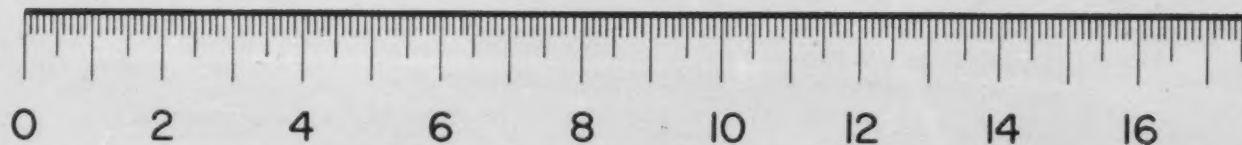




DECIMAL SCALE COMPARISON

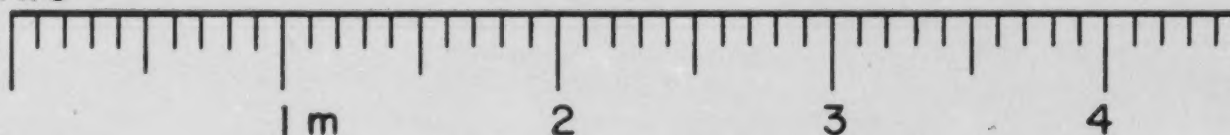
CUSTOMARY

50



METRIC

1:50



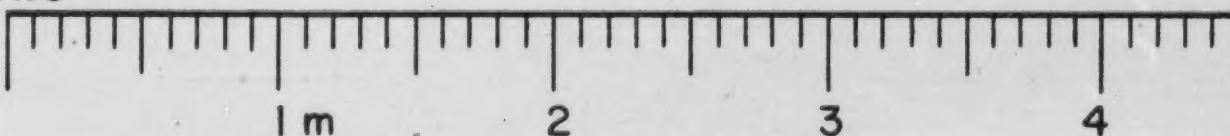
CUSTOMARY

60



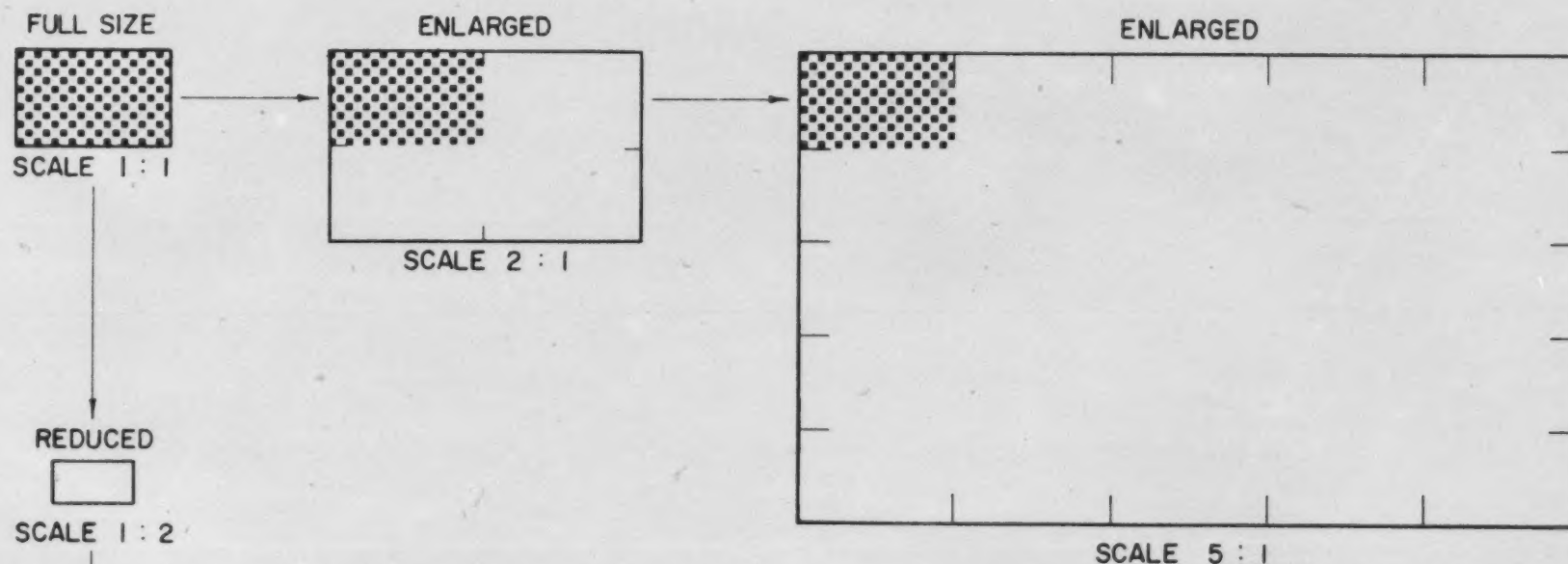
METRIC

1:50





ENLARGEMENT AND REDUCTION SCALES



THE USUAL METRIC SCALES ARE :

FULL SIZE 1 : 1

ENLARGEMENT 2 : 1 5 : 1 10 : 1 20 : 1 50 : 1

REDUCTION 1 : 2 1 : 5 1 : 10 1 : 20 1 : 50



Decimals of an inch to millimetres

in	mm	in	mm	in	mm
0.001	0.025	0.01	0.254	0.1	2.54
0.002	0.051	0.02	0.508	0.2	5.08
0.003	0.076	0.03	0.762	0.3	7.62
0.004	0.102	0.04	1.016	0.4	10.16
0.005	0.127	0.05	1.270	0.5	12.70
0.006	0.152	0.06	1.524	0.6	15.24
0.007	0.178	0.07	1.778	0.7	17.78
0.008	0.203	0.08	2.032	0.8	20.32
0.009	0.229	0.09	2.286	0.9	22.86

157

158

159

160

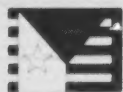
+

+



Decimals of an inch to millimetres (rounded values)

in	mm	in	mm	in	mm
0.001	0.02	0.01	0.2	0.1	2.5
0.002	0.05	0.02	0.5	0.2	5.1
0.003	0.08	0.03	0.8	0.3	7.6
0.004	0.10	0.04	1.0	0.4	10.2
0.005	0.13	0.05	1.3	0.5	12.7
0.006	0.15	0.06	1.5	0.6	15.2
0.007	0.18	0.07	1.8	0.7	17.8
0.008	0.20	0.08	2.0	0.8	20.3
0.009	0.23	0.09	2.3	0.9	22.9



Fractions of an inch to millimetres

in		mm	in		mm	in		mm	in		mm
1/64	0.016	0.397	17/64	0.266	6.747	33/64	0.516	13.097	49/64	0.766	19.447
1/32	0.031	0.794	9/32	0.281	7.144	17/32	0.531	13.494	25/32	0.781	19.844
3/64	0.047	1.191	19/64	0.297	7.541	35/64	0.547	13.891	51/64	0.797	20.241
1/16	0.062	1.588	5/16	0.312	7.938	9/16	0.562	14.288	13/16	0.812	20.638
5/64	0.078	1.984	21/64	0.328	8.334	37/64	0.578	14.684	53/64	0.828	21.034
3/32	0.094	2.381	11/32	0.344	8.731	19/32	0.594	15.081	27/32	0.844	21.431
7/64	0.109	2.778	23/64	0.359	9.128	39/64	0.609	15.478	55/64	0.859	21.828
1/8	0.125	3.175	3/8	0.375	9.525	5/8	0.625	15.875	7/8	0.875	22.225
9/64	0.141	3.572	25/64	0.391	9.922	41/64	0.641	16.272	57/64	0.891	22.622
5/32	0.156	3.969	13/32	0.406	10.319	21/32	0.656	16.669	29/32	0.906	23.019
11/64	0.172	4.366	27/64	0.422	10.716	43/64	0.672	17.066	59/64	0.922	23.416
3/16	0.188	4.762	7/16	0.438	11.112	11/16	0.688	17.462	15/16	0.938	23.812
13/64	0.203	5.159	29/64	0.453	11.509	45/64	0.703	17.859	61/64	0.953	24.209
7/32	0.219	5.556	15/32	0.469	11.906	23/32	0.719	18.256	31/32	0.969	24.606
15/64	0.234	5.953	31/64	0.484	12.303	47/64	0.734	18.653	63/64	0.984	25.003
1/4	0.250	6.350	1/2	0.500	12.700	3/4	0.750	19.050	1	1.000	25.400



Inches to millimetres

in	mm	in	mm	in	mm	in	mm
1	25.4	26	660.4	51	1295.4	76	1930.4
2	50.8	27	685.8	52	1320.8	77	1955.8
3	76.2	28	711.2	53	1346.2	78	1981.2
4	101.6	29	736.6	54	1371.6	79	2006.6
5	127.0	30	762.0	55	1397.0	80	2032.0
6	152.4	31	787.4	56	1422.4	81	2057.4
7	177.8	32	812.8	57	1447.8	82	2082.8
8	203.2	33	838.2	58	1473.2	83	2108.2
9	228.6	34	863.6	59	1498.6	84	2133.6
10	254.0	35	889.0	60	1524.0	85	2159.0
11	279.4	36	914.4	61	1549.4	86	2184.4
12	304.8	37	939.8	62	1574.8	87	2209.8
13	330.2	38	965.2	63	1600.2	88	2235.2
14	355.6	39	990.6	64	1625.6	89	2260.6
15	381.0	40	1016.0	65	1651.0	90	2286.0
16	406.4	41	1041.4	66	1676.4	91	2311.4
17	431.8	42	1066.8	67	1701.8	92	2336.8
18	457.2	43	1092.2	68	1727.2	93	2362.2
19	482.6	44	1117.6	69	1752.6	94	2387.6
20	508.0	45	1143.0	70	1778.0	95	2413.0
21	533.4	46	1168.4	71	1803.4	96	2438.4
22	558.8	47	1193.8	72	1828.8	97	2463.8
23	584.2	48	1219.2	73	1854.2	98	2489.2
24	609.6	49	1244.6	74	1879.6	99	2514.6
25	635.0	50	1270.0	75	1905.0	100	2540.0



Millimetres to inches

mm	in	mm	in	mm	in	mm	in
1	0.039	26	1.024	51	2.008	76	2.992
2	0.079	27	1.063	52	2.047	77	3.031
3	0.118	28	1.102	53	2.087	78	3.071
4	0.157	29	1.142	54	2.126	79	3.110
5	0.197	30	1.181	55	2.165	80	3.150
6	0.236	31	1.220	56	2.205	81	3.189
7	0.276	32	1.260	57	2.244	82	3.228
8	0.315	33	1.299	58	2.283	83	3.268
9	0.354	34	1.338	59	2.323	84	3.307
10	0.394	35	1.378	60	2.362	85	3.346
11	0.433	36	1.417	61	2.402	86	3.386
12	0.472	37	1.457	62	2.441	87	3.425
13	0.512	38	1.496	63	2.480	88	3.464
14	0.551	39	1.535	64	2.520	89	3.504
15	0.590	40	1.575	65	2.559	90	3.543
16	0.630	41	1.614	66	2.598	91	3.583
17	0.669	42	1.654	67	2.638	92	3.622
18	0.709	43	1.693	68	2.677	93	3.661
19	0.748	44	1.732	69	2.716	94	3.701
20	0.787	45	1.772	70	2.756	95	3.740
21	0.827	46	1.811	71	2.795	96	3.780
22	0.866	47	1.850	72	2.835	97	3.819
23	0.906	48	1.890	73	2.874	98	3.858
24	0.945	49	1.929	74	2.913	99	3.898
25	0.984	50	1.968	75	2.953	100	3.937



ROUND-OFF RULES

TOTAL TOLERANCE IN INCHES		MILLIMETRE CONVERSION ROUNDED TO
AT LEAST	LESS THAN	
0.00001	0.0001	5 DECIMAL PLACES
0.0001	0.001	4 DECIMAL PLACES
0.001	0.01	3 DECIMAL PLACES
0.01	0.1	2 DECIMAL PLACES
0.1	1.0	1 DECIMAL PLACE

TOTAL TOLERANCE IN MILLIMETRES		INCH CONVERSION ROUNDED TO
AT LEAST	LESS THAN	
0.005	0.05	5 DECIMAL PLACES
0.05	0.5	4 DECIMAL PLACES
0.5	5.0	3 DECIMAL PLACES
5.0 AND OVER		2 DECIMAL PLACES



METRIC LINEAR SIZES

Preferred basic millimetre sizes for engineering

	Rising by 5	Rising by 10	Rising by 20	Rising by 50
1	20	80	200	300
1.2	25	90	220	350
1.6	30	100	240	400
2	35	110	260	450
2.5	40	120	280	500
3	45	130	300	550
4	50	140		600
5	55	150		650
6	60	160		700
8	65	170		750
10	70	180		800
12	75	190		850
16	80	200		900
20				950
				1000



PREFERRED METRIC SIZES FOR ENGINEERING

SIZES 1mm to 10mm	
1st	CHOICE
1	
1.2	
1.6	
2	
2.5	
3	
4	
5	
6	
8	
10	

SIZES 10mm to 100mm	
1st	CHOICE
10	
12	
16	
20	
25	
30	
40	
50	
60	
80	
100	

SIZES 100mm to 1000mm	
1st	CHOICE
100	
120	
160	
200	
250	
300	
400	
500	
600	
800	
1000	

+

+

2nd	2nd	2nd
1.1	11	110
1.4	14	140
1.8	18	180
2.2	22	220
2.8	28	280
3.5	35	350
4.5	45	450
5.5	55	550
7	70	700
9	90	900

+

+

3rd		3rd		3rd
				105
				115
1.3		13	130	125
				135
1.5		15	150	145
				155
1.7		17	170	165
				175
1.9		19	190	185
				195
2.1		21	210	
2.4		23	230	
		24	240	
2.6		26	260	
				270
				290
3.2	32		320	
		34		340
		36		360
3.8	38		380	
4.2	42		420	
		44		440
		46		460
4.8	48		480	
5.2	52		520	
		54		540
		56		560
5.8	58		580	
		62	620	
6.5	65		650	640
				660
		68	680	
		72	720	
7.5	75		750	740
				760
		78	780	
		82		820
8.5	85		850	880
		88		
		92		920
9.5	95		950	980
		98		

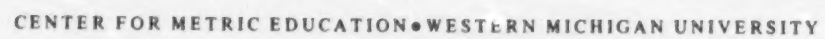


Figure 1 is a schematic diagram of a rectangular area, likely a lake or reservoir, divided into six sub-areas (A1 to A6) for a water quality study. The overall dimensions are 1189 m by 841 m. The diagram shows a large rectangle with a dashed diagonal line from the top-left to the bottom-right. A vertical line divides the rectangle into two main sections. The left section is labeled A1. The right section is further divided into A2 (top) and A3 (bottom). A3 is further divided into A4 (top) and A5 (bottom). A5 is further divided into A6 (top) and an unlabeled bottom section. The dimensions 1189 m and 841 m are indicated at the top and right respectively.

1189 mm x 841 mm = 1 SQUARE METRE

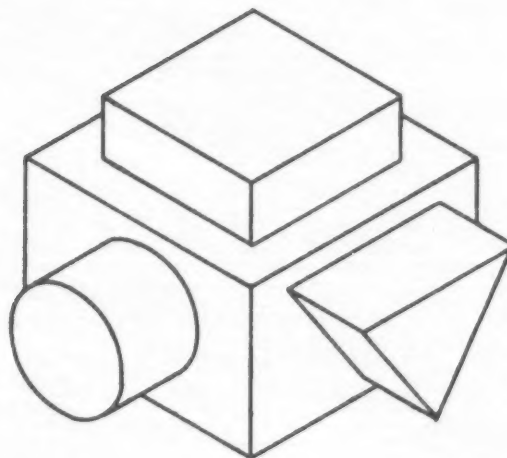


COMPARISON CHART - A SIZE PAPER

ISO-sizes	METRIC-millimetres	CUSTOMARY-Inches
2A	1189 x 1682	46.81 x 66.22
A0	841 x 1189	33.11 x 46.81
A1	594 x 841	23.39 x 33.11
A2	420 x 594	16.54 x 23.39
A3	297 x 420	11.69 x 16.54
A4	210 x 297	8.27 x 11.69
A5	148 x 210	5.83 x 8.27
A6	105 x 148	4.13 x 5.83
A7	74 x 105	2.91 x 4.13
A8	52 x 74	2.05 x 2.91
A9	37 x 52	1.46 x 2.05
A10	26 x 37	1.02 x 1.46

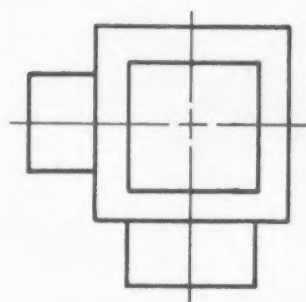
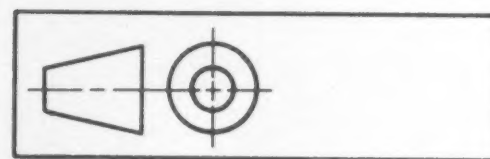
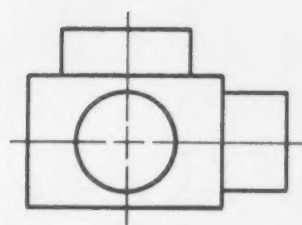
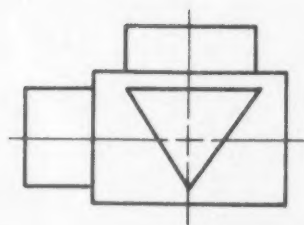


ORTHOGRAPHIC PROJECTION COMPARISON



178

179



180

181

+

+

FRONT
ELEVATION

END
VIEW

FIRST
ANGLE
PROJECTION

TOP (PLAN)
VIEW

182

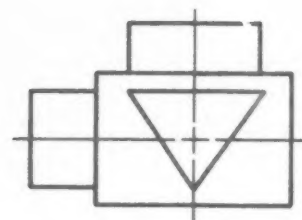
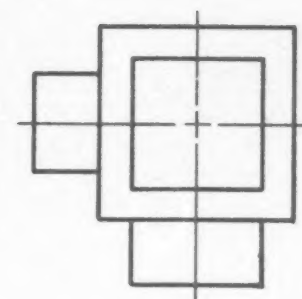
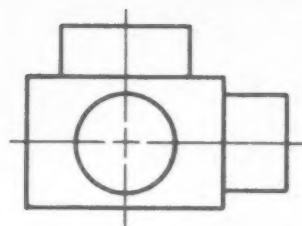
183

+

+



184



185

+

+

THIRD
ANGLE
PROJECTION

186

END
VIEW

TOP (PLAN)
VIEW

FRONT
ELEVATION

187





ABBREVIATIONS

(SOME FORMER ABBREVIATIONS ARE NOW SYMBOLS)

Across flats	ACR FLT
Centers	CTR
Center line	CL
Centimetre	cm
Chamfer	CHAM
Counterbore	CBORE
Countersink	CSK
Countersunk head	CSK H
Diameter (before the dimension)	Ø
Diameter (in a note)	DIA
Drawing	DWG
Figure	FIG
Hexagon	HEX
Hexagonal head	HEX HD

Inside diameter	ID
Left hand	LH
Material	MATL
Metre	m
Millimetre	mm
Number	NO
Outside diameter	OD
Pitch diameter	PD
Radius (before the dimension)	R
Right hand	RH
Round	RD
Square (before the dimension)	□
Square (in a note)	SQ
Thread	THD

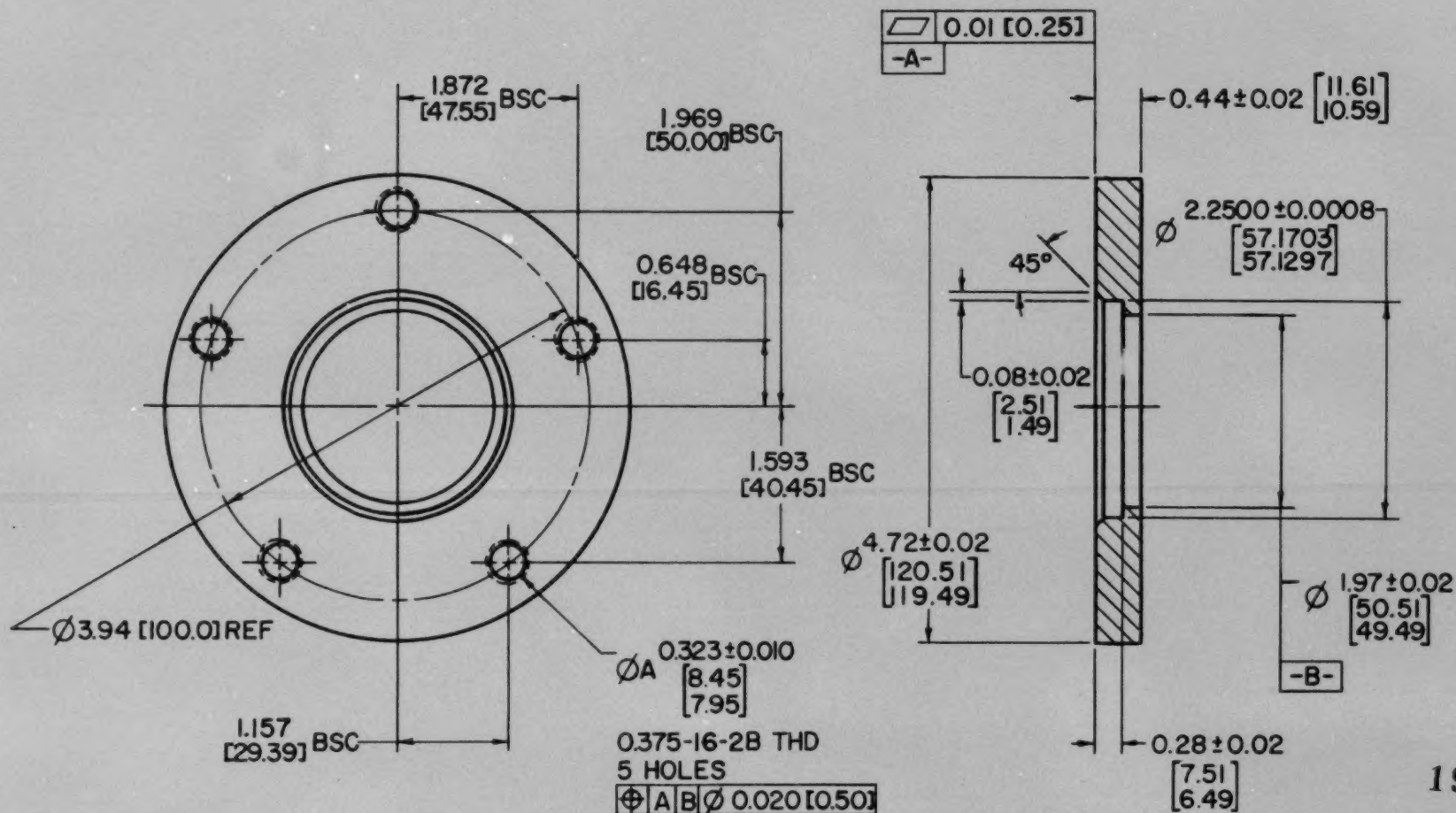


GEOMETRIC CHARACTERISTIC SYMBOLS

CHARACTERISTIC	ANSI Y14.5	ISO
STRAIGHTNESS	—	—
FLATNESS		
ANGULARITY		
PERPENDICULARITY (SQUARENESS)		
PARALLELISM	OR //	//
CONCENTRICITY	● OR ◎	◎
TRUE POSITION		
ROUNDNESS (CIRCULARITY)		
SYMMETRY		
PROFILE OF ANY LINE		
PROFILE OF ANY SURFACE (CONTOUR)		
RUNOUT		
CYLINDRICITY		
DATUM FEATURE		
MAXIMUM MATERIAL CONDITION (MMC)		
REGARDLESS OF FEATURE SIZE (RFS)		NONE (ASSUMED UNLESS SPECI- FIED MMC)



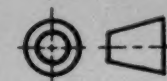
DUAL DIMENSIONING



DIM. IN [] ARE MILLIMETRES

UNLESS OTHERWISE SPECIFIED:
 $\pm 1^\circ$ TOL ON ANGULAR DIM.
FINISH ALL OVER

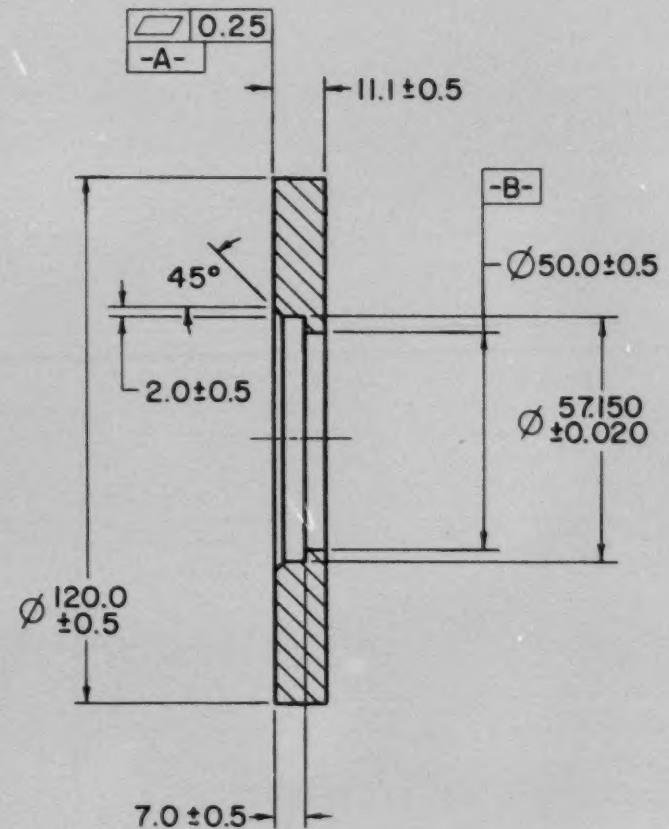
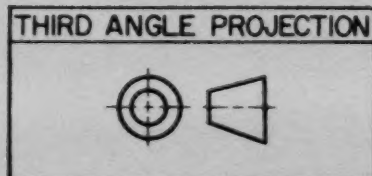
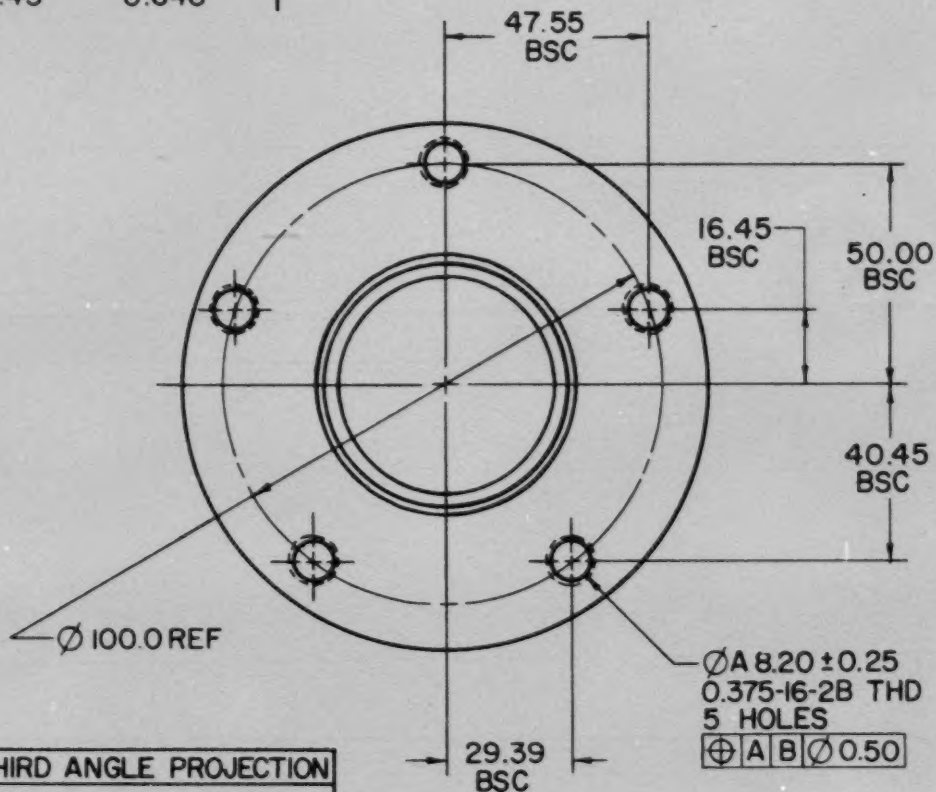
THIRD ANGLE PROJECTION





MASTER DIMENSIONING (WITH CUSTOMARY READOUT CHART)

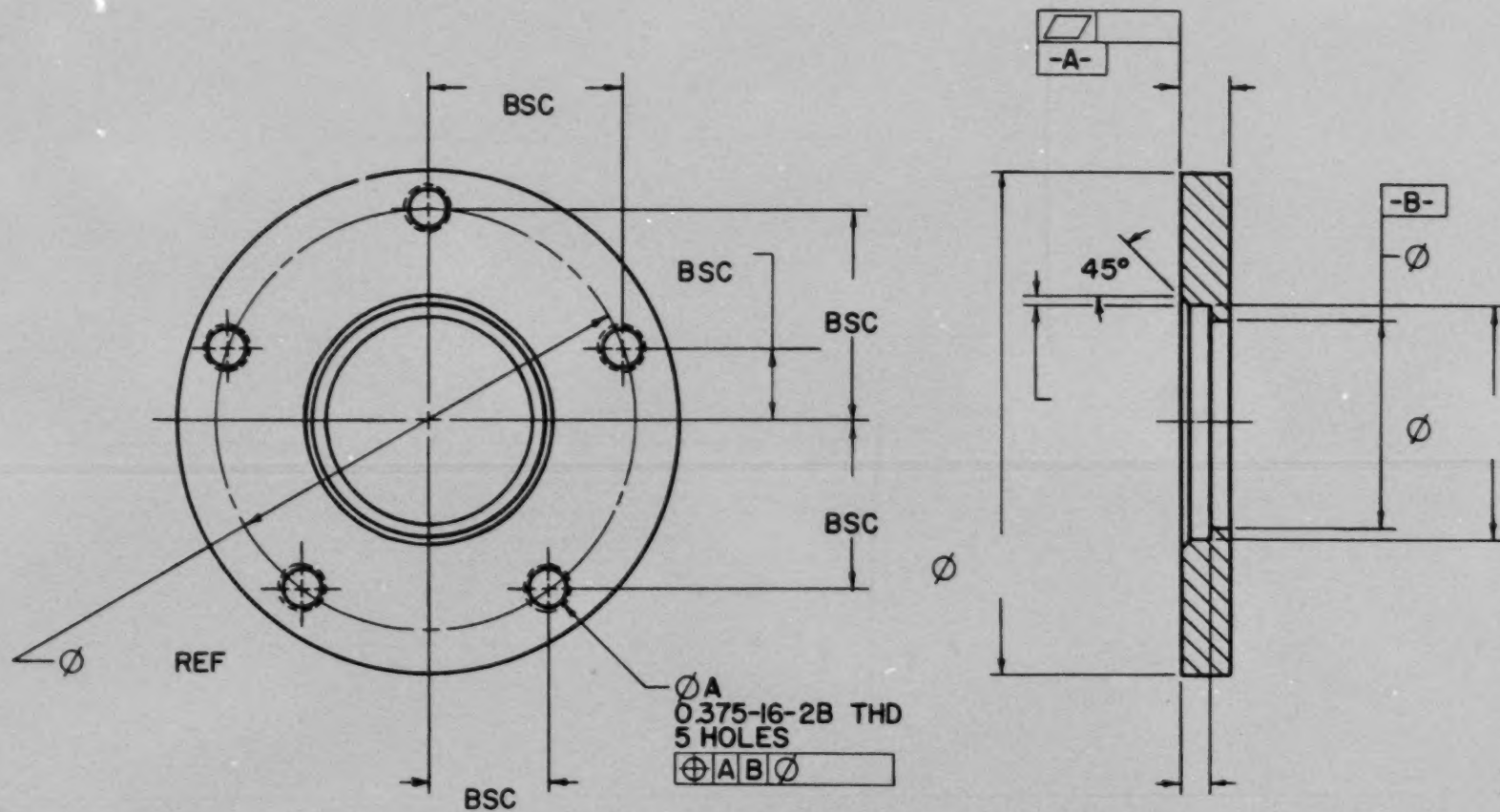
CONVERSION			
mm	inch	mm	inch
0.020	0.0008	29.39	1.157
0.25	0.010	40.45	1.593
0.5	0.02	47.55	1.872
0.50	0.020	50.0	1.97
2.0	0.08	50.00	1.969
7.0	0.28	57.150	2.2500
8.20	0.323	100.0	3.94
11.1	0.44	120.0	4.72
16.45	0.648		



UNLESS OTHERWISE SPECIFIED:
±1° TOL ON ANGULAR DIM.
FINISH ALL OVER

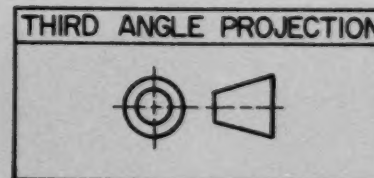


MASTER UNIDIMENSIONING



195

UNLESS OTHERWISE SPECIFIED:
±1° TOL ON ANGULAR DIM.
FINISH ALL OVER



USOE SPONSORED PROJECT NO. V257006
GRANT NO. O EG-0-72-1868

196

METRIC

47.55

0.25

11.1 ± 0.5

16.45

50.0 ± 0.5

50.00

2.0 ± 0.5

57.150
± 0.020

40.45

120.0
± 0.5

100.0

820 ± 0.25

29.39

0.50

7.0 ± 0.5

197

198

+

+

CUSTOMARY

0.01

1.872

0.44 ± 0.02

0.648

1.97 ± 0.02

1.969

0.08 ± 0.02

2.2500 ± 0.0008

1.593

4.72 ± 0.02

3.94

0.323 ± 0.010

1.157

0.020

0.28 ± 0.02

199

200

+

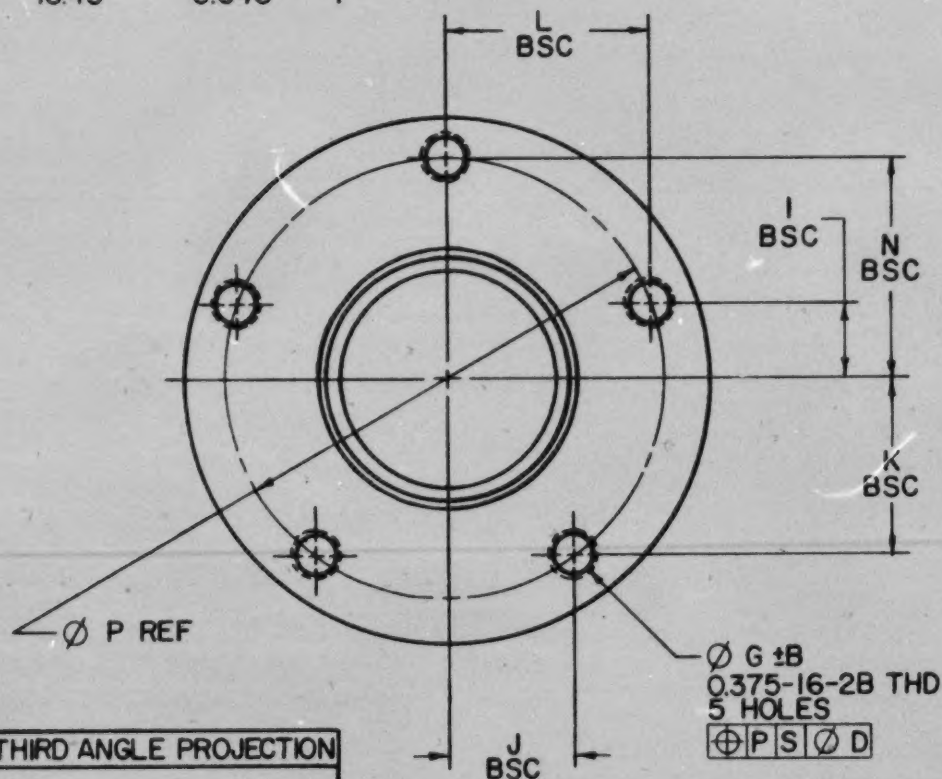
+



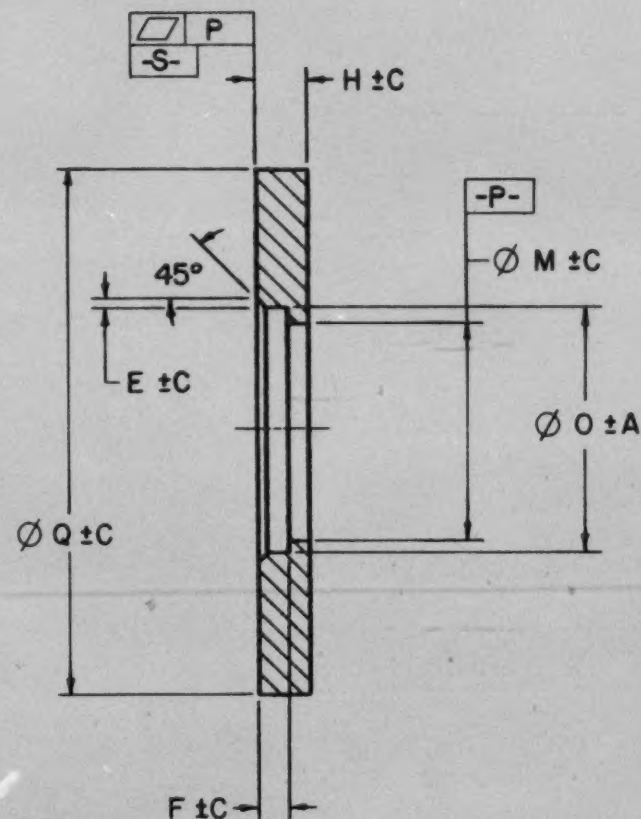
IDENTIFICATION LETTER DIMENSIONING

CONVERSION

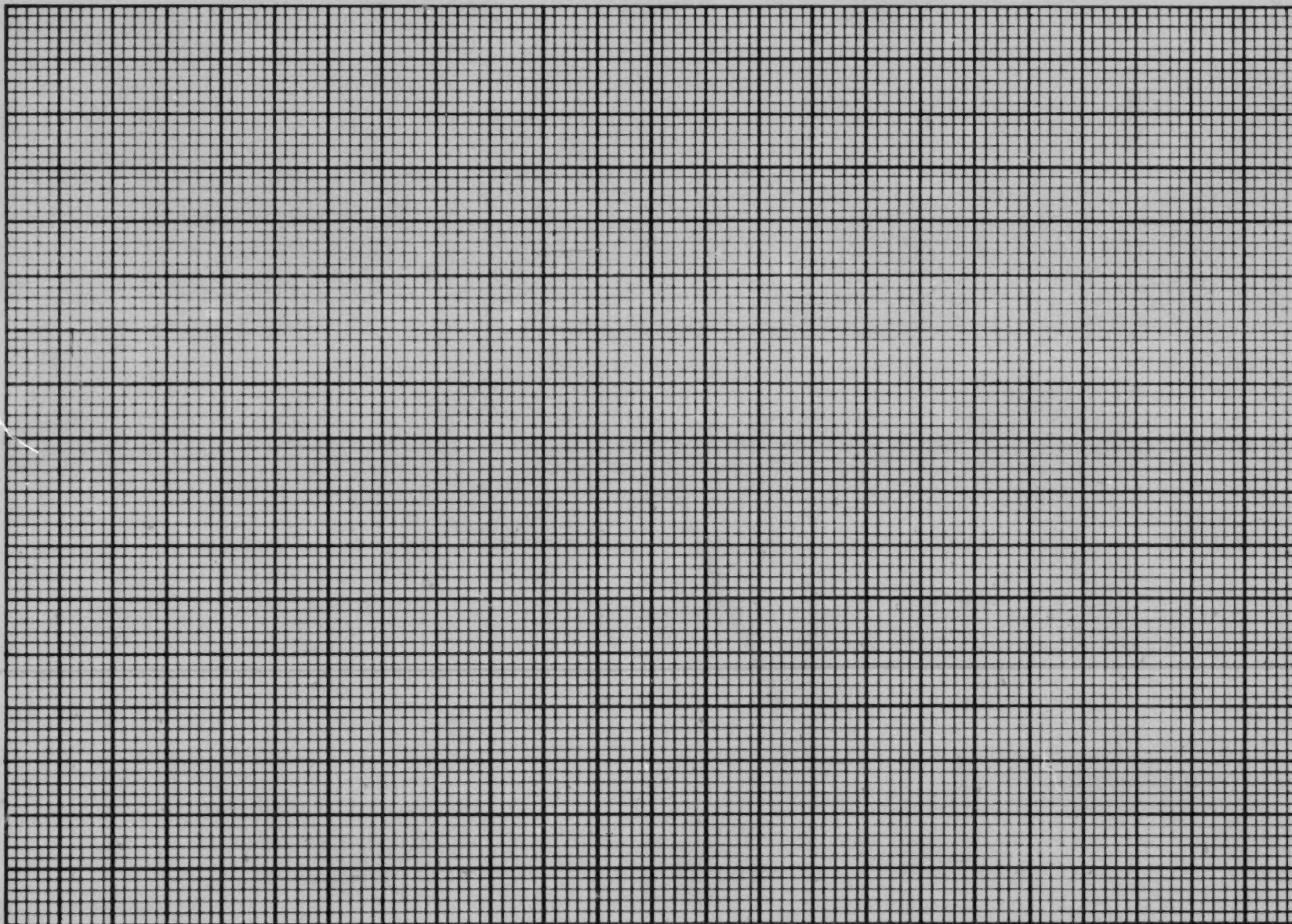
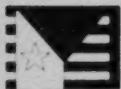
	mm	inch		mm	inch
A	0.020	0.0008	J	29.39	1.157
B	0.25	0.010	K	40.45	1.593
C	0.5	0.02	L	47.55	1.872
D	0.50	0.020	M	50.0	1.97
E	2.0	0.08	N	50.00	1.969
F	7.0	0.28	O	57.150	2.2500
G	8.20	0.323	Q	100.0	3.94
H	11.1	0.44	R	120.0	4.72
I	16.45	0.648			



UNLESS OTHERWISE SPECIFIED:
±1° TOL ON ANGULAR DIM.
FINISH ALL OVER



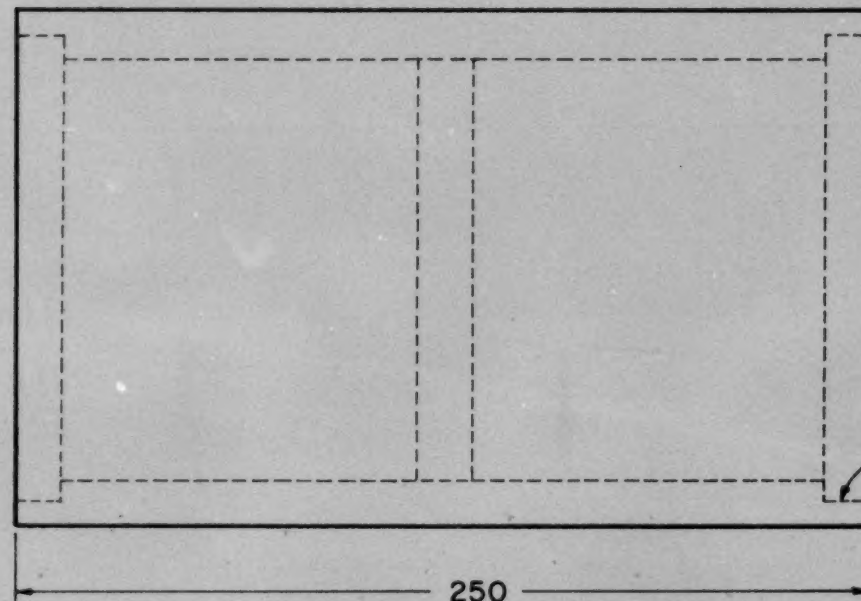
DATUM SURFACES:
P = PRIMARY
S = SECONDARY



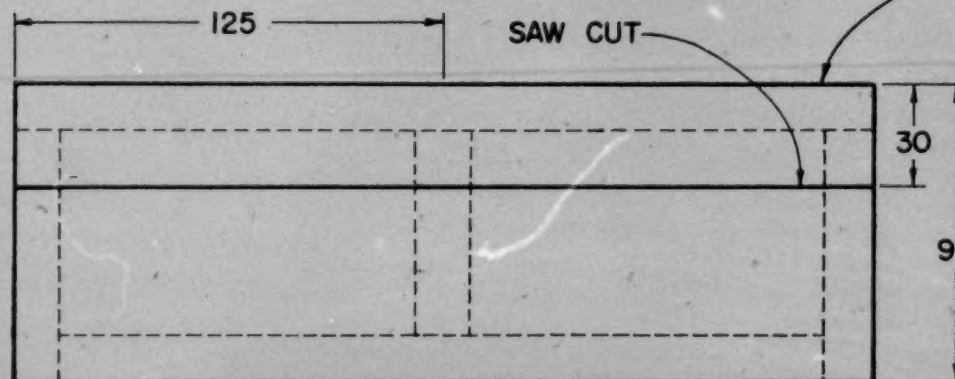


METRIC DRAWING - WOODWORKING (VENEERED BOX)

CONVERSION CHART		
mm	decimal inch	inch to nearest 16th
30	1.181	1 3/16
75	2.953	2 15/16
91	3.583	3 9/16
125	4.921	4 15/16
150	5.905	5 7/8
250	9.842	9 13/16



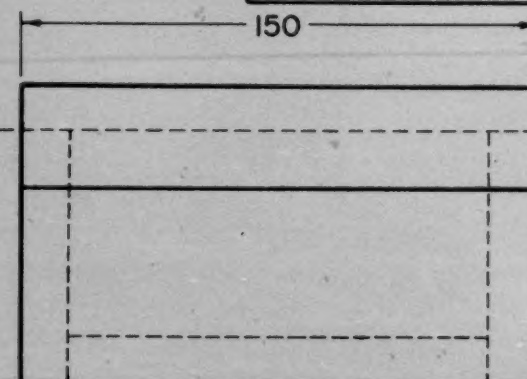
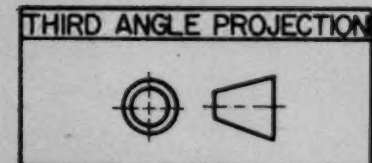
RABBET JOINT
4 PLACES

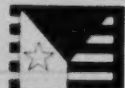


1 mm VENEER

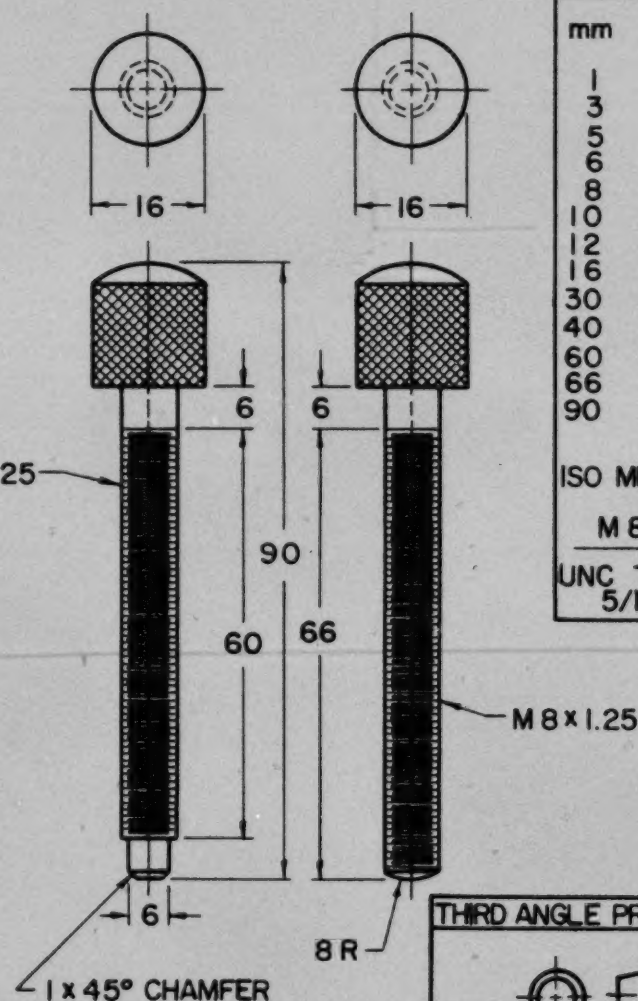
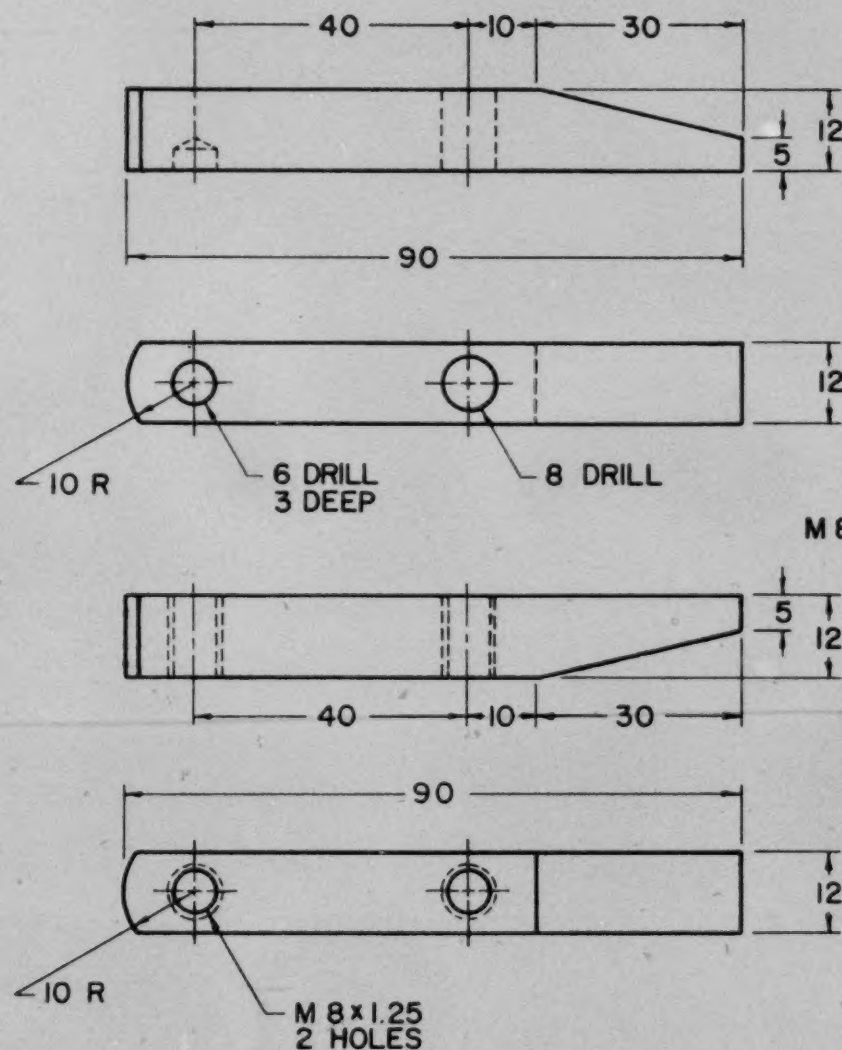
NOTE:

16 mm BASSWOOD USED
HARDWARE TO SUIT



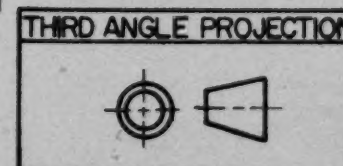


METRIC DRAWING - METALWORKING (TOOLMAKER'S CLAMP)



CONVERSION CHART	
mm	inch
1	0.039
3	0.118
5	0.197
6	0.236
8	0.315
10	0.394
12	0.472
16	0.630
30	1.181
40	1.575
60	2.362
66	2.598
90	3.543

ISO METRIC
THREAD
M 8 x 1.25
UNC THREAD
5/16-18-UNC





COMPARISON OF COMMON THREAD SIZES

ISO METRIC THREAD

COARSE THREAD SERIES



M 10 x 1.5 - 6g

THREAD SYMBOL FOR ISO

NOMINAL SIZE IN MILLIMETRES

PITCH IN MILLIMETRES

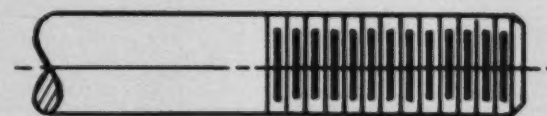
THREAD TOLERANCE CLASS SYMBOL

NOTE -

THE METRIC THREAD ILLUSTRATED IS A LITTLE LARGER IN DIAMETER THAN 3/8" AND HAS ALMOST 17 THREADS PER INCH.

UNIFIED NATIONAL

COARSE THREAD SERIES



3/8 - 16 UNC - 2A

MAJOR DIA

THREADS PER INCH

THREAD SERIES

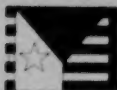
CLASS

24 x 3	1-8
	7/8-9
20 x 2.5	3/4-10
	5/8-11
16 x 2	9/16-12
	1/2-13
12 x 1.75	7/16-14
	3/8-16
10 x 1.5	5/16-18
8 x 1.25	1/4-20
	12-24
6 x 1	10-24
5 x .8	8-32
	6-32
4 x .7	5-40
	4-40
3 x .5	3-48
2.5 x .45	2-56
2 x .4	

**ISO Metric Thread—Coarse Series**

Diameter	2	2.5	3	4	5	6	8	10
Pitch	0.4	0.45	0.5	0.7	0.8	1.0	1.25	1.5
Basic effective diameter ...	1.740	2.208	2.675	3.545	4.480	5.350	7.188	9.026
Depth of thread in screw	0.25	0.28	0.31	0.43	0.49	0.61	0.77	0.92
Area of Root dia. (mm ²) ...	1.79	2.98	4.47	7.75	12.7	17.9	32.8	52.3
Diameter of tapping drill	1.6	2.05	2.5	3.3	4.2	5.0	6.8	8.5

Diameter	12	16	20	24	30	36	42	48
Pitch	1.75	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Basic effective diameter ...	10.863	14.701	18.376	22.051	27.727	33.402	39.077	44.752
Depth of thread in screw	1.07	1.23	1.53	1.84	2.15	2.45	2.76	3.07
Area of Root dia. (mm ²) ...	76.2	144	225	324	519	759	1050	1380
Diameter of tapping drill	10.2	14.0	17.5	21.0	26.5	32.0	37.5	43.0

**ISO Metric Thread—Fine Series**

Diameter	8	10	12	14	16	18	20
Pitch	1.0	1.25	1.25	1.5	1.5	1.5	1.5
Basic effective dia. ...	7.350	9.188	11.188	13.026	15.026	17.026	19.026
Depth of thread in screw	0.61	0.77	0.77	0.92	0.92	0.92	0.92
Area of Root dia. (mm ²) ...	36.0	56.3	86.0	116	157	205	259
Diameter of tapping drill	7.0	8.8	10.8	12.5	14.5	16.5	18.5

Diameter	22	24	30	36	42	48
Pitch	1.5	2.0	2.0	3.0	3.0	3.0
Basic effective diameter ...	21.026	22.701	28.701	34.051	40.051	46.051
Depth of thread in screw	0.92	1.23	1.23	1.84	1.84	1.84
Area of Root dia. (mm ²) ...	319	365	586	820	1210	1540
Diameter of tapping drill	20.5	22.0	28.0	33.0	39.0	45.0



ISO METRIC THREAD FORM

P = PITCH in mm

$H = 0.86603P$

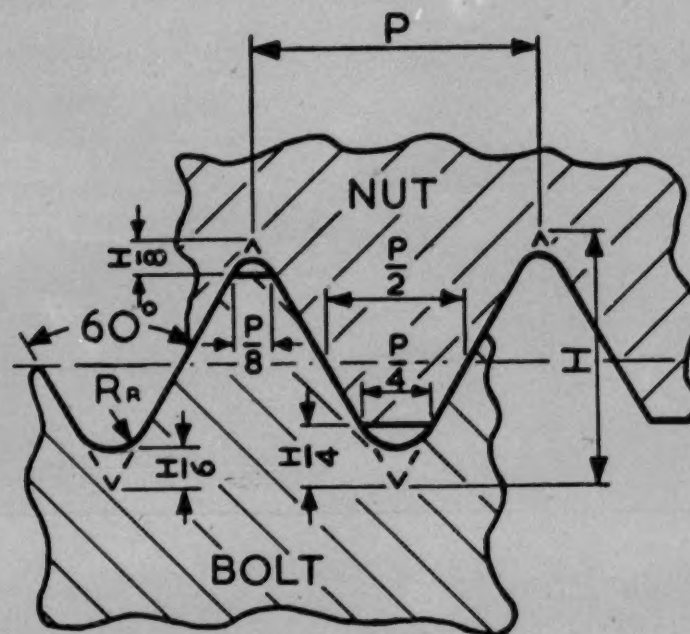
$\frac{H}{4} = 0.21651P$

$\frac{H}{6} = 0.14434P$ $\frac{H}{8} = 0.10825P$

$R_R = 0.14434P$

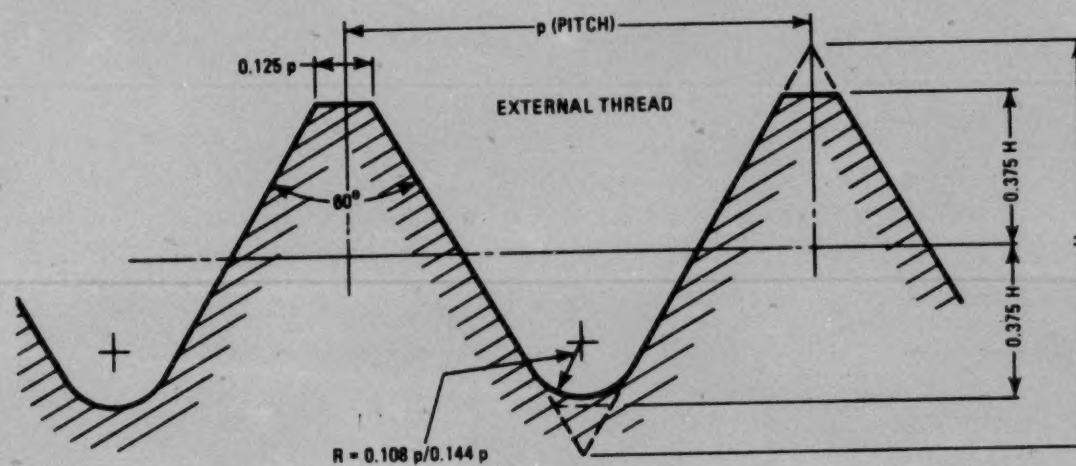
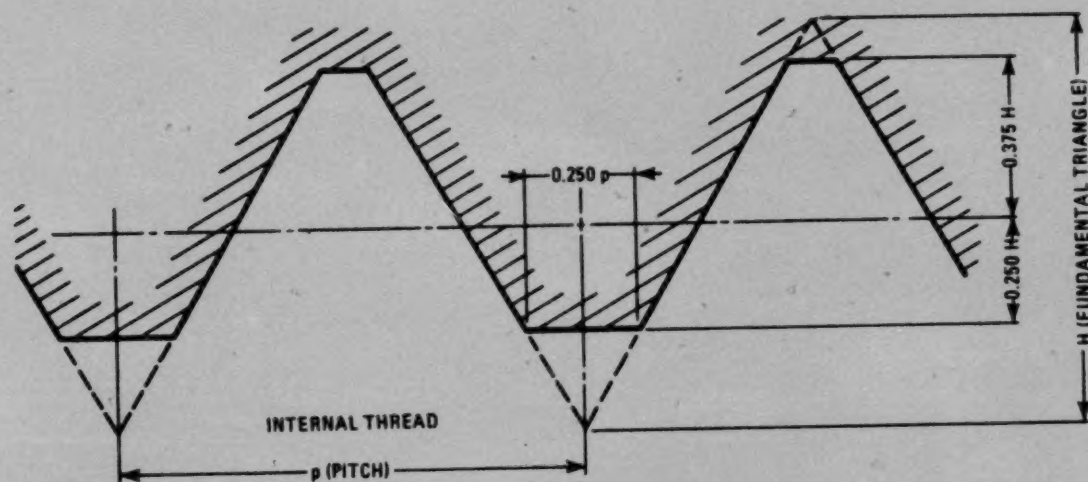
Depth
of thread in screw = $\frac{17}{24} H = 0.61343P$

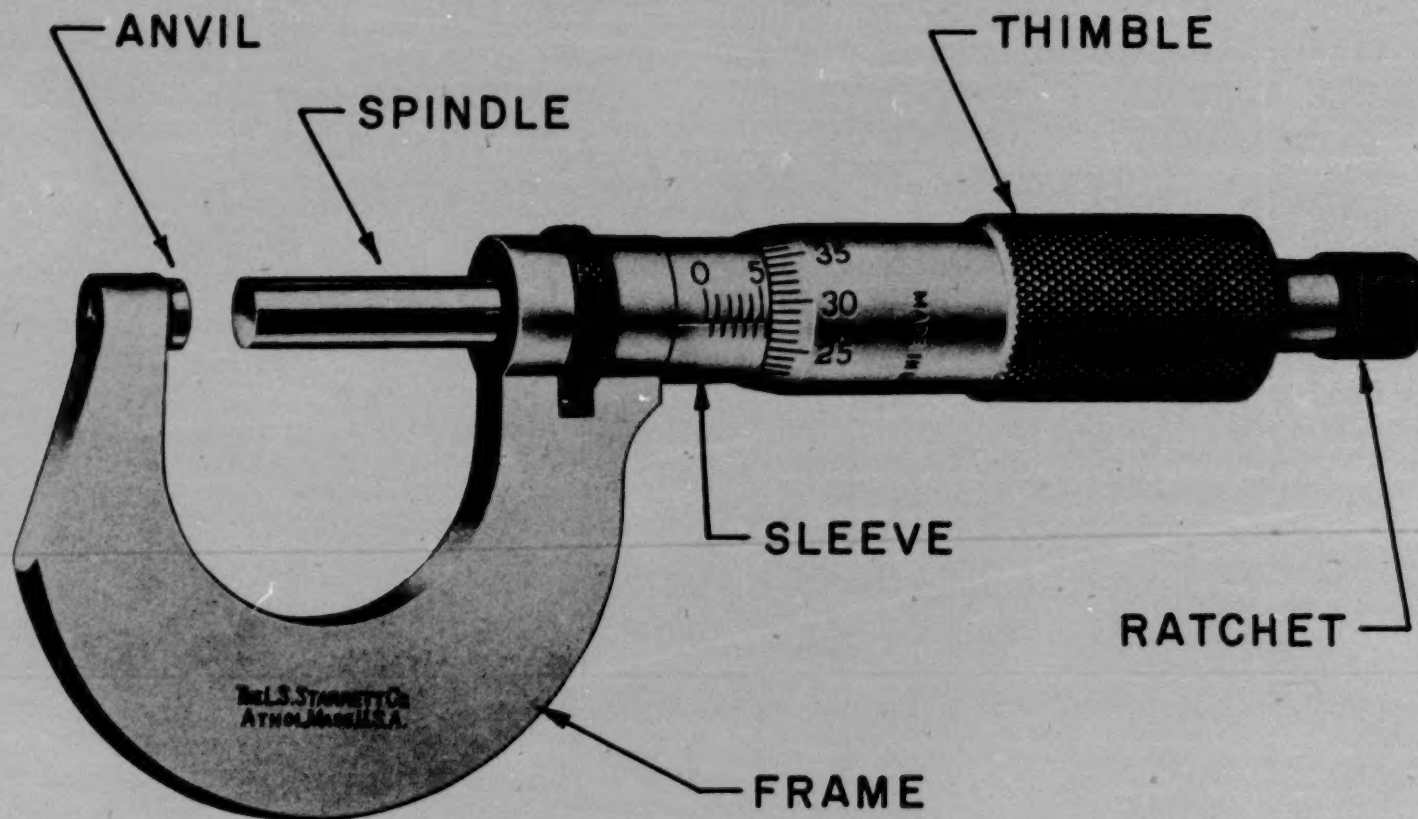
Depth
of thread in nut = $\frac{5}{8} H = 0.54127P$

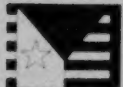




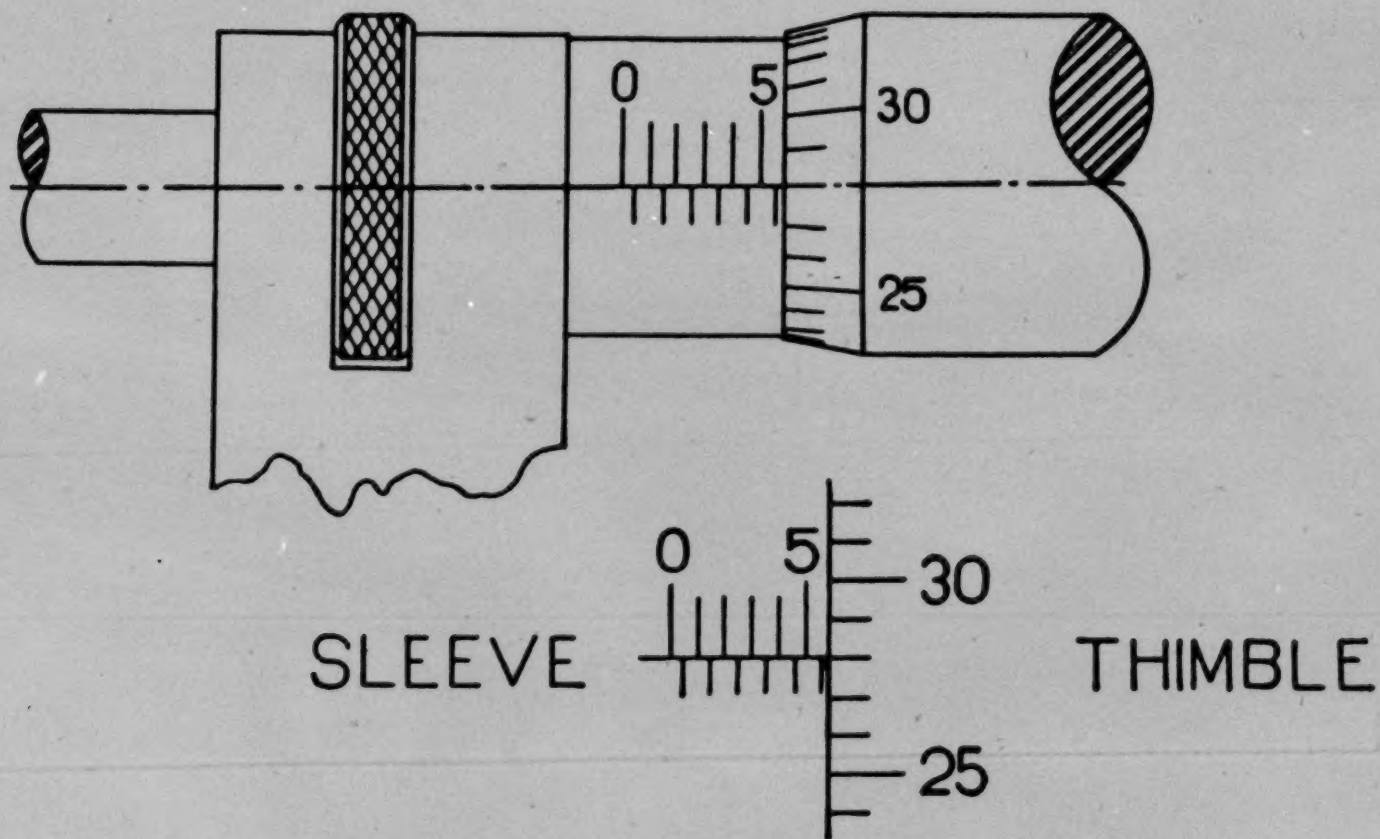
THREAD FORM - ISO METRIC AND ISO INCH SERIES







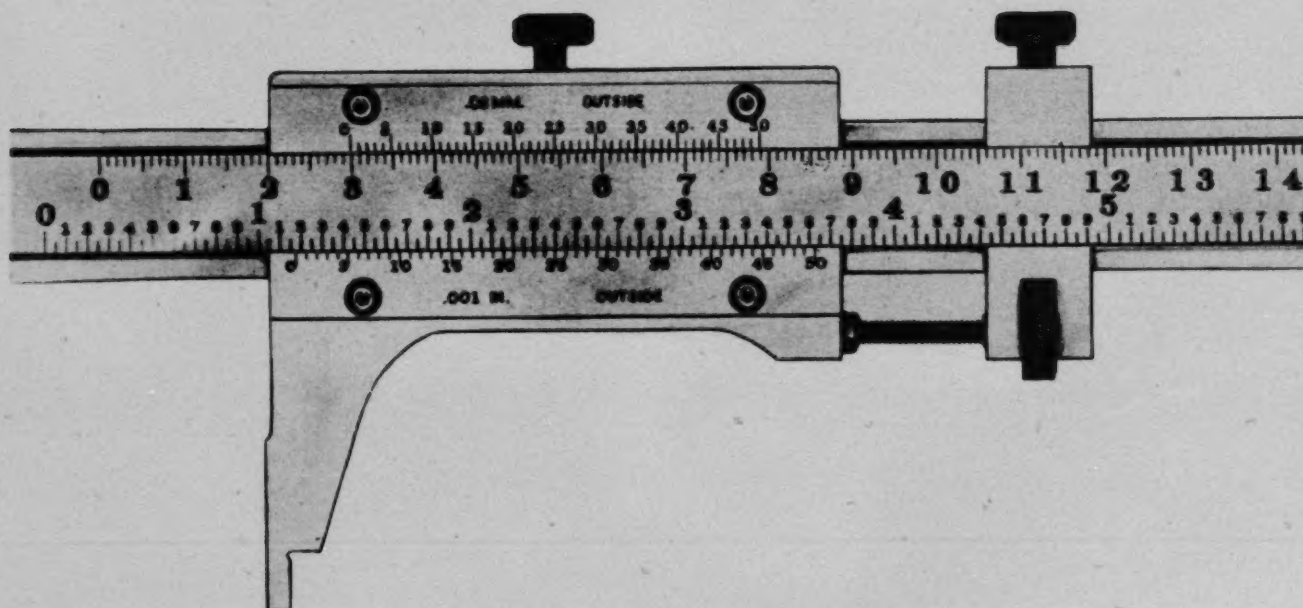
READING A METRIC MICROMETER



READING 5.78 mm



CUSTOMARY-METRIC VERNIER CALIPER

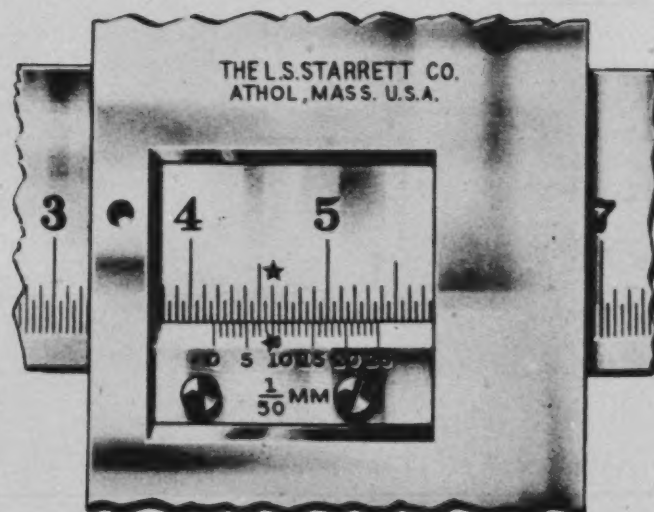


If the metric reading is 30 mm, the customary reading to three decimal places is:

- A. 1. 152
- B. 1. 300
- C. 1. 181
- D. 1. 120



METRIC VERNIER CALIPER



The correct reading is: 41.00 mm
0.50 mm
0.18 mm (9/50 mm)

Total 41.68 mm

GOING METRIC IN METALWORKING -- NOTES AND COMMENTS

The metric measurement and ISO standards will have its greatest impact on the metal manufacturing industry. Therefore, students in any program of general metals or machine shop should become thoroughly acquainted with the measuring system, metric measuring tools, and ISO standards for metric threads and other items. It is recommended that the student review the basic student kit and that the teacher use the transparencies in the GOING METRIC FOR CAREER TEACHERS before the metalworking area is covered.

1. A MILLIMETRE IS ABOUT HALF WAY BETWEEN THE $1/32"$ & THE $1/16"$.

Rulers are available either combining the customary and the metric rule, or as an all metric rule. The metric rules are divided into centimetres, millimetres, and sometimes half millimetres as the finest measurement. Often, the number lines represent centimetres and are numbered 1, 2, 3, 4 representing a centimetre. Other metric rules have the numbered lines marked 10, 20, 30, 40, etc., representing millimetres. Many metalworking industries use metric rules and drafting scales, showing all measurement in millimetres for easy measuring. Note that 1 millimetre is about half way between the 16th and 32nd, and a $1/2$ millimetre about half way between a 32nd and a 64th.

2. 12 mm -- 28 mm -- 42 mm . This metric rule is marked in centimetres on the numbered lines so that number 1 represents

10 mm . In reading the measurement, 2 small divisions past the 1 equal 12 mm or approximately $1\frac{1}{2}$ ".

3. OUTSIDE/INSIDE DIAMETER. This shows how to use a metric rule to make inside and outside measurements. Note that the outside diameter is 36 mm and the inside diameter is 32 mm.
4. PARTS OF A METRIC MICROMETER. This is a standard reading metric micrometer. Each of the lines above the datum line represents a full millimetre. Each line below represents a half millimetre. There are 50 divisions around the thimble, each representing 0.01 millimetre.
5. READING A METRIC MICROMETER. Note that 5 full lines above the datum line are visible. This represents 5.00 millimetres. A half line is visible below the datum line and this represents 0.50 millimetre. Each divisions on the thimble represents 0.01 mm . There are 28 division showing on the thimble representing 0.28 millimetre so that the final reading is 5.00 plus 0.50 plus 0.28 which equals 5.78 mm .
6. METRIC VERNIER CALIPER. There are several types of vernier scales used on the metric vernier calipers. The main beam of the caliper is divided into numbered lines each representing centimetres, longer division lines representing millimetres, and short division lines representing half millimetres. The vernier is divided into 25 equal divisions. Each small division represents 0.02 millimetre. To read this correctly,

note that the zero line on the vernier scale is three small divisions past 4. The 4 represents 40 millimetres. The next largest line represents 1 millimetre for a total of 41 millimetres. The small line on the beam represents 0.50 millimetre. Note that the 9 line on the vernier lines up directly with the line on the beam. Since each of these lines represent 0.02 mm, you must multiply by 9 so that the resultant is 0.18. The reading equals 41.00 mm plus 0.50 mm plus 0.18 mm for a total reading of 41.68 mm .

7. CUSTOMARY-METRIC VERNIER CALIPER. Note that this is a combination of customary/metric vernier caliper.
8. DIAL INDICATOR. The dial indicator has a range of 2.5 mm with 0.01 mm graduations.
9. FEELER GAGES. These thickness gages have blades marked in millimetres.
10. THREAD FORM -- ISO METRIC AND ISO INCH SERIES. Note that the thread form is identical for the ISO metric and the ISO inch (commonly known as the unified national thread form). However, the threads are not interchangeable.
11. COMPARISON OF COMMON THREAD SIZES. The ISO metric thread (coarse series) compared with the unified national, UNC coarse series, (also known as the ISO inch series). Note that in the metric series the diameter is shown in millimetres, the pitch (which is the distance from the top of one thread to the top of the next) is shown in millimetres and the tolerance is also given when necessary. Remember that in

the metric threads the pitch is given, while in the unified national series the number of threads per inch is given. Even though these two threads appear very close in size and number of threads, they are not interchangeable because the metric thread has almost 17 threads per inch, while the unified national has 16 threads per inch.

12. THREADS: EXTERNAL/INTERNAL. This illustrates how to designate external and internal threads. The M represents metric, 12 the diameter in millimetres, 1.75 the pitch, and the 6g the tolerance which is a medium class of fit. Lower-case letters are used for indicating tolerance on external threads and capital letters for internal threads. Note that the nut would be stamped M12-6H. Unless otherwise specified, only the metric coarse series is used; therefore, the pitch is not needed.
13. ISO METRIC THREAD FORM. This illustrates details of the internal and external threads and how the dimensions are determined.
14. ISO METRIC THREAD--COARSE SERIES. The 12 sizes that are in tinted form represent approximately 90% of the metric threads used in average manufacturing. Note how simple it is to arrive at the correct tapping drill size. Merely subtract the pitch from the diameter to secure the tap drill in millimetres. For example, if the pitch is 4, then the tap drill size will be 3.3 millimetres.

15. ISO METRIC THREAD--FINE SERIES. This series is rarely used except for precision measuring instruments. ISO metric threads in the fine series are difficult to purchase since they are not in common use.
16. THREAD PITCH GAGE. To identify the size of a metric thread, measure the diameter with a metric micrometer or a metric hole gage and then check the pitch with this thread pitch gage.
17. ISO INCH AND ISO METRIC THREADS. Note the comparative size of the ISO metric and ISO inch threads. Altogether, there are 57 sizes of metric threads and 59 sizes of inch threads in common use.
18. OVERLAY. The Industrial Fasteners Institute (IFI) has recommended 25 sizes in a single pitch series in metric threads that would replace both the ISO metric and the ISO inch sizes. Note that most of the recommended sizes are identical to a select number of the ISO coarse thread series. However, some of the sizes are not the same; therefore, it may be a problem of securing international agreement on the IFI metric thread series.
19. SIZE STAMPED ON WRENCH. All fixed sizes of wrenches require a different set for metric threads. This is because the distance across the flats of the heads are not compatible with the inch sizes. Always use a wrench stamped the same size as the size of the head or nut.

20. DUAL DIMENSIONING. There are four basic methods of dimensioning a drawing so that the part can be produced into metric sizes. The first and most common method is the dual dimensioning. In this method the customary size is shown above and the metric size is shown below or after. This is perhaps the poorest method of dimensioning because it results in a crowded looking drawing and a very difficult drawing to use. Dual dimensioning also results in more machining errors (about 70% based on British experience).
21. MASTER DIMENSIONING (WITH CUSTOMARY READOUT CHART). A common method used by many of the heavy industrial equipment manufacturers is to dimension in metric only and then provide a conversion chart for these metric sizes. This conversion chart is pasted on the drawing so that it can be removed when necessary. There is a trend toward even eliminating this conversion chart so that all workers begin to "think metric."
22. MASTER UNIDIMENSIONING. This type is used by some industries where the drafting room makes the master drawing without dimensioning. Copies are then made.
23. OVERLAY. The metric dimensions are added to one copy.
24. OVERLAY. The customary dimensions to the other copy.
25. IDENTIFICATION LETTER DIMENSIONING. This method has been recommended by some groups. It is not particularly successful. This method requires that the dimensions be

shown with capital letters only. A conversion chart is added which will give the correct dimensions in millimetres and in inches. The difficulty with this drawing is that constant reference from the drawing to the conversion chart must be made. This causes errors.

26. METRIC DRAWING--METALWORKING. This typical toolmaker's clamp can be easily made of standard materials available in the average school lab. The only extra equipment necessary is a metric tap and die set for the more common metric threads.
27. METRIC DIMENSIONING. Add the metric measurement to this drawing of a hammer head.
28. VALVE BODY. This is a typical valve body showing all the dimensions in millimetres. Note the use of rounded-off millimetre sizes.
29. METAL CUTTING LATHE. Some adaptations must be made to most metal cutting lathes to produce materials to metric sizes.
30. OVERLAY. The basic changes are shown in this overlay.
31. METAL CUTTING LATHE. This modern, heavy-duty lathe is equipped with a gear box that will cut both ISO metric and unified national threads. The only changes necessary are two dual reading dials for the cross-feed and compound rest.
32. OVERLAY.
33. METRIC/ENGLISH DUAL READING DIAL. One of the most common dual reading dials is one with a gear arrangement that shows the

customary (English) graduations on one half of the dial and the metric graduations on the other.

34. DUAL READING DIAL. In this type of dual reading dial there is a reducing gear that provides for the metric reading.
35. DUAL READING DIAL. Another type of dual reading dial uses a tape arrangement.
36. DIGITAL READOUT EQUIPMENT. The best method to use for heavy industrial equipment is to buy digital readout equipment that will show dimensions either in the customary or metric system. A flip of the switch will change the reading from customary to the metric reading.
37. TEMPERATURES, STEEL COLORS, AND RELATED PROCESSES. The heat treating chart shows hardening and tempering temperatures in degrees Fahrenheit and degrees Celsius.

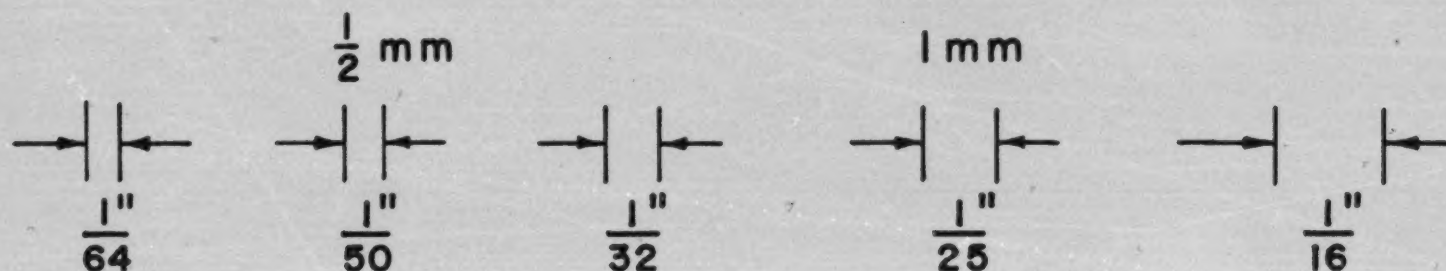


A MILLIMETRE IS ABOUT HALF WAY BETWEEN THE $\frac{1}{32}$ " & THE $\frac{1}{16}$ ".

$\frac{1}{2}$ MILLIMETRE IS ABOUT HALF WAY BETWEEN THE $\frac{1}{32}$ " & THE $\frac{1}{64}$ ".



(ENLARGED 10 TIMES ACTUAL SIZE.)



EXACT DIMENSIONAL READING IN INCHES:

0.015625

0.031250

0.062500

0.019685

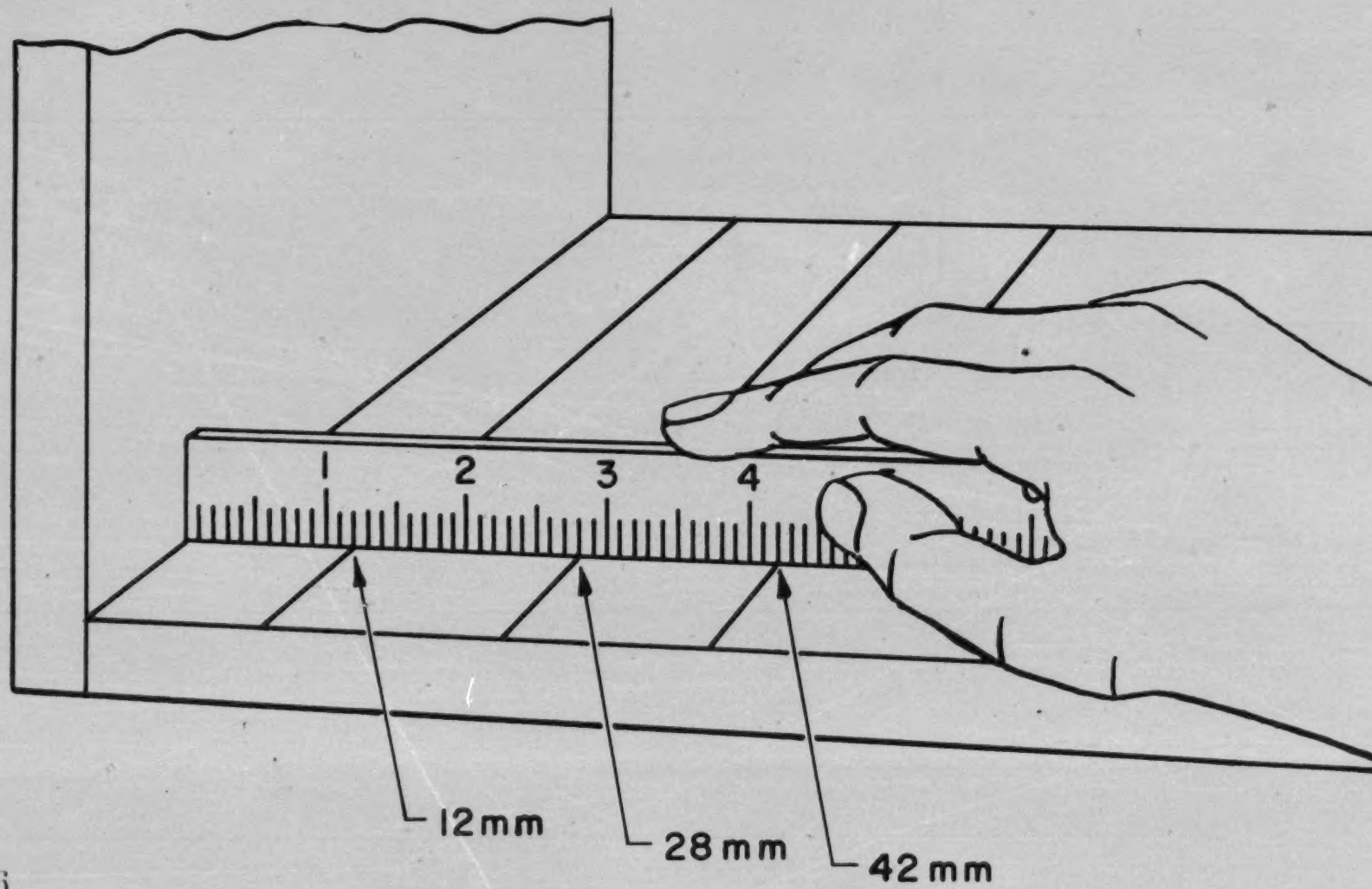
0.039370

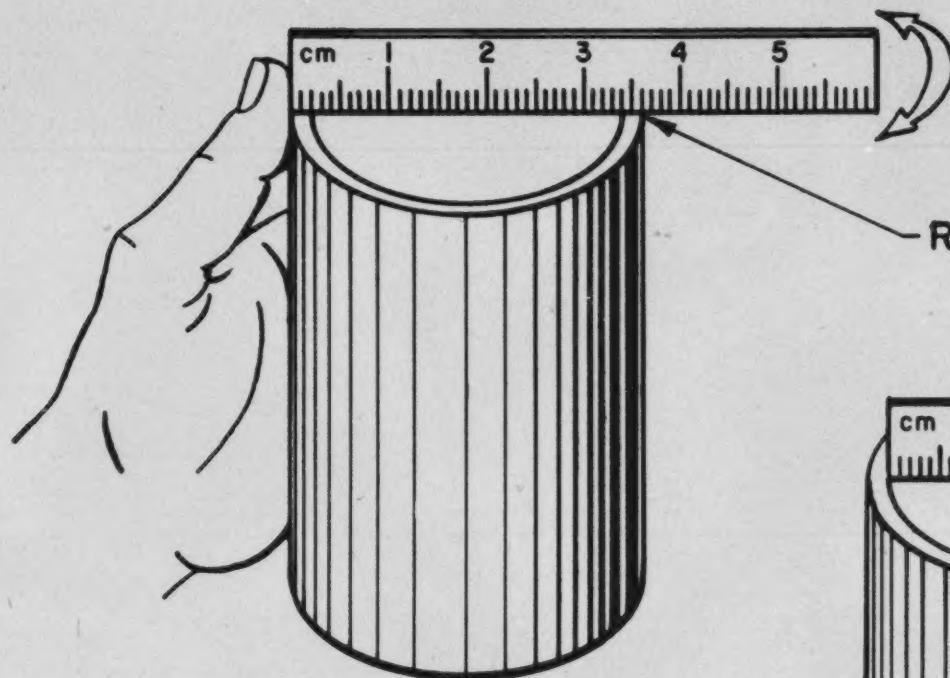
EXACT DIMENSIONAL READING IN MILLIMETRES:

0.396875

0.793750

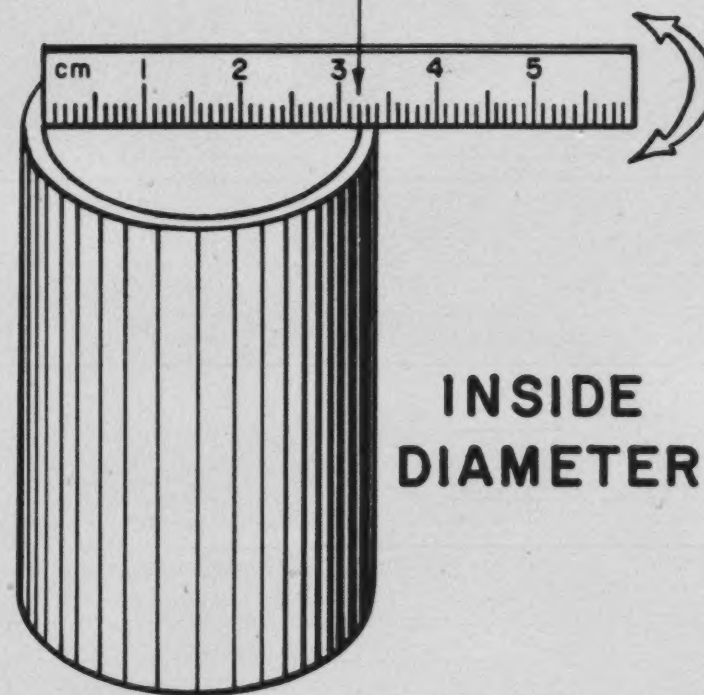
1.587500



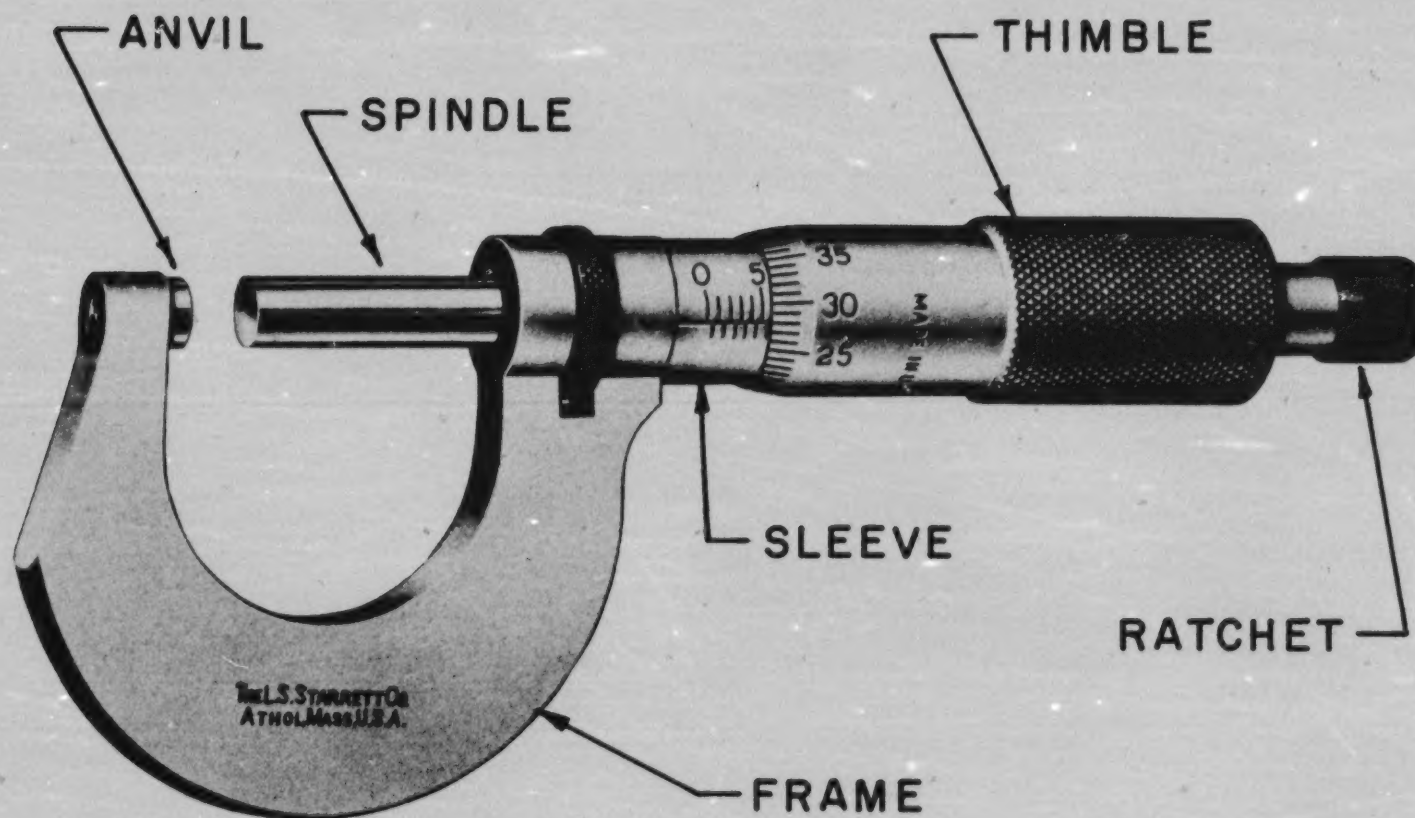


**OUTSIDE
DIAMETER**

READ MEASUREMENT HERE.

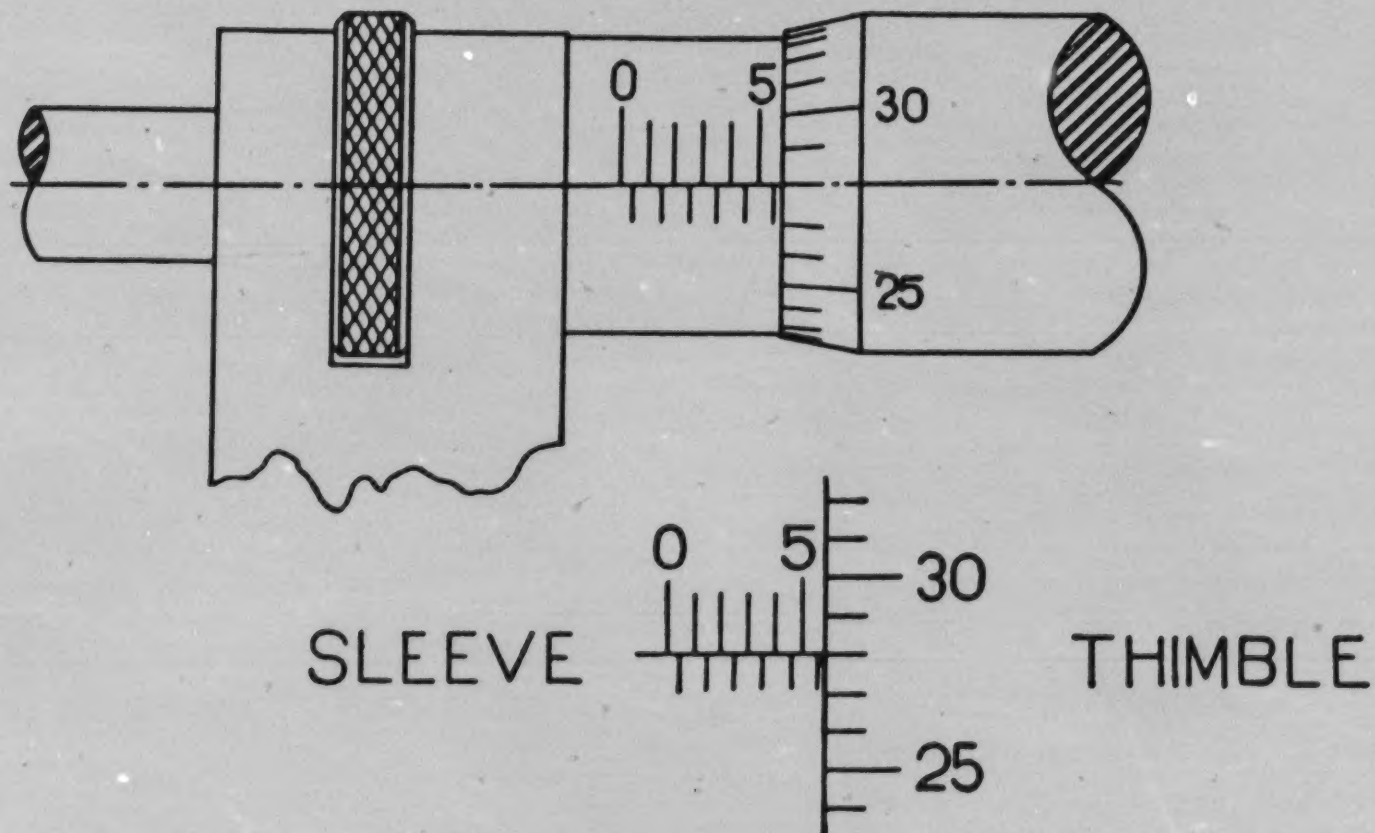


**INSIDE
DIAMETER**





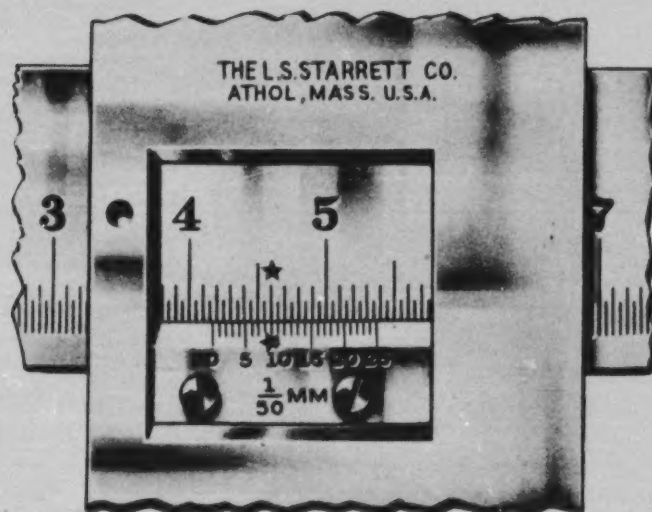
READING A METRIC MICROMETER



READING 5.78 mm



METRIC VERNIER CALIPER

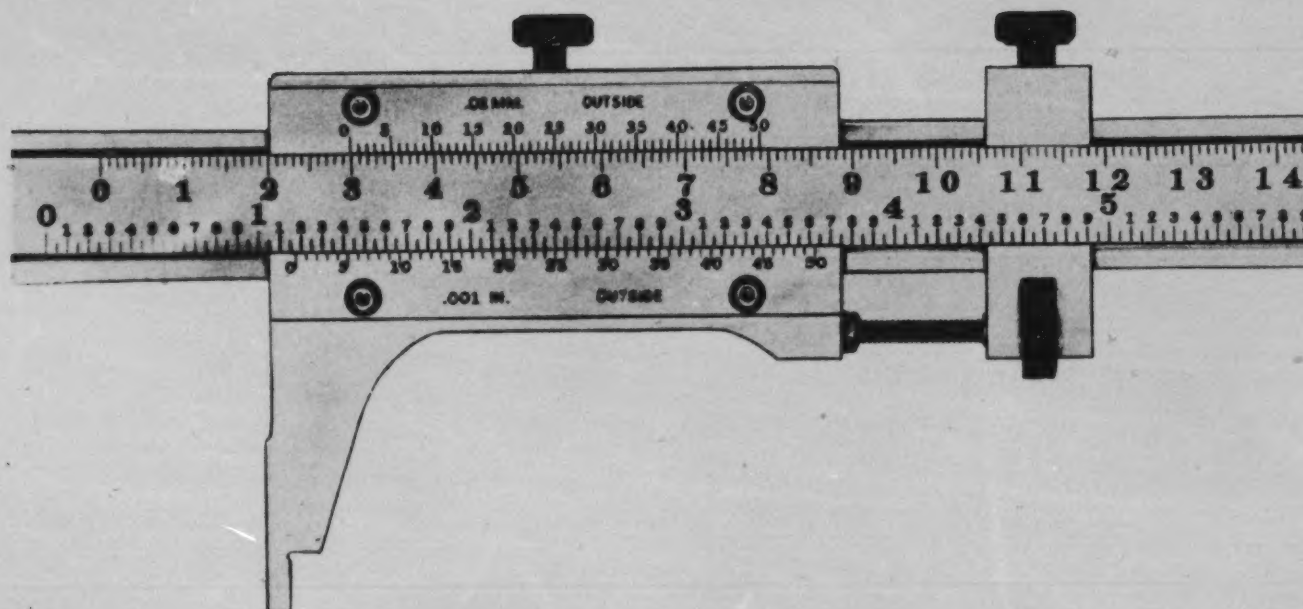


The correct reading is: 41.00 mm
0.50 mm
0.18 mm (9/50 mm)

Total 41.68 mm



CUSTOMARY-METRIC VERNIER CALIPER



If the metric reading is 30 mm, the customary reading to three decimal places is:

- A. 1. 152
- B. 1. 300
- C. 1. 181
- D. 1. 120



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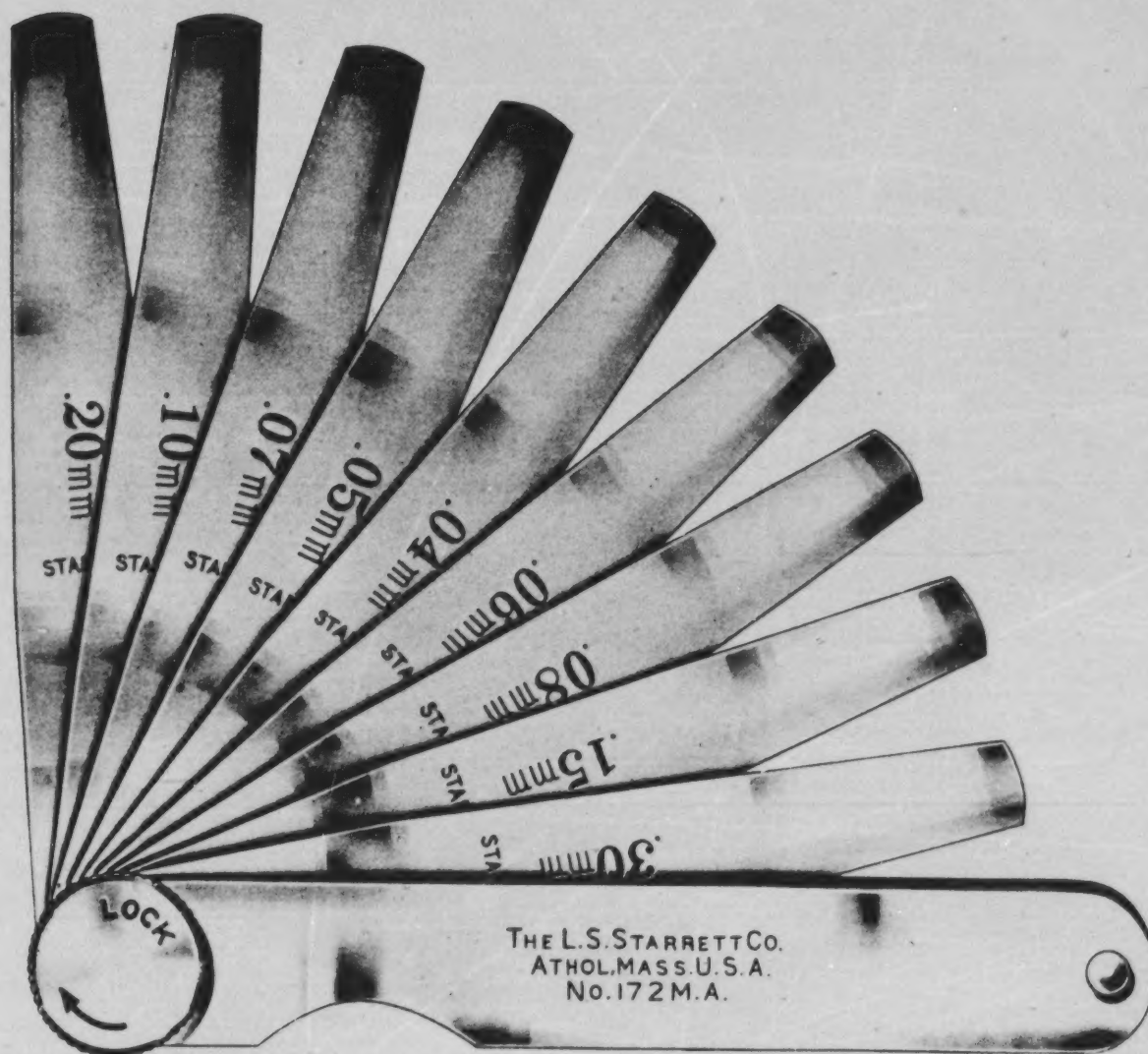


247

USOE SPONSORED PROJECT NO. V2
GRANT NO. O EG-0-72-1868



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248

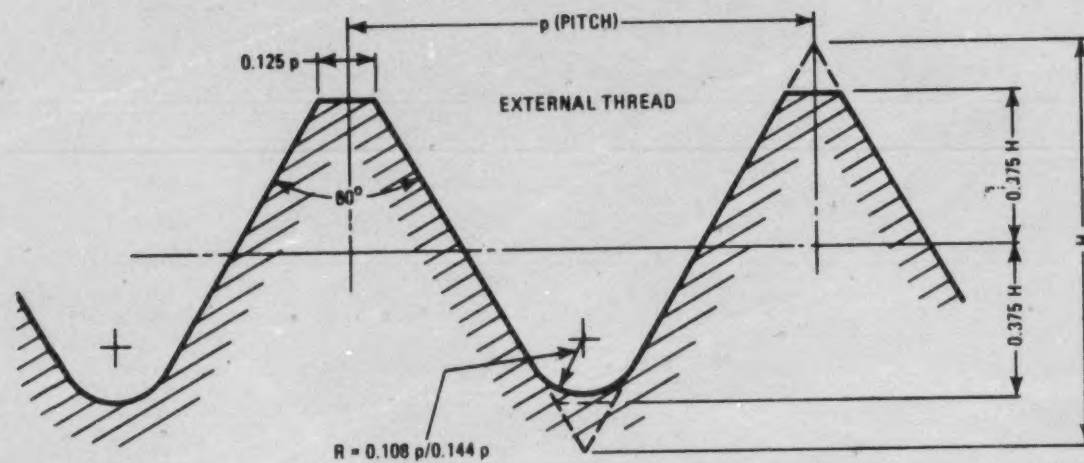
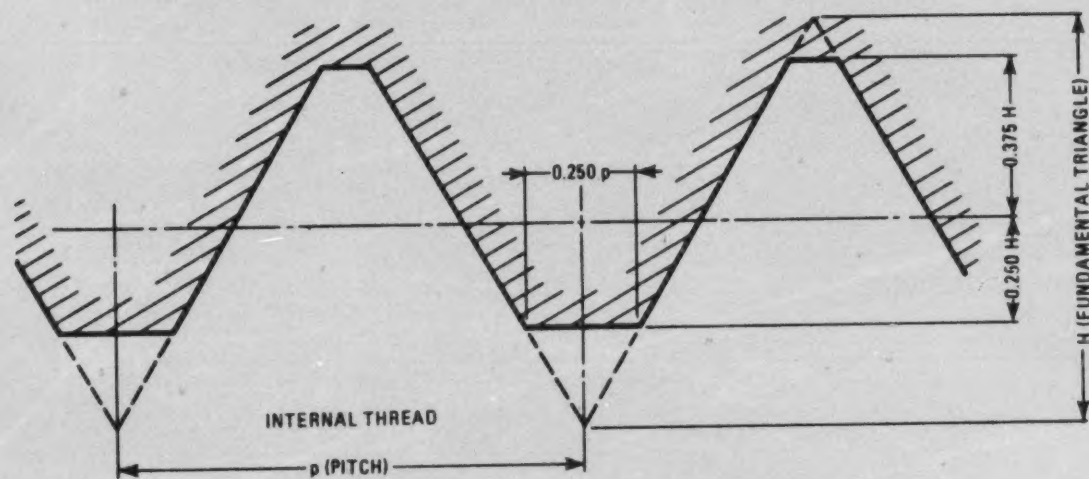
249

USOE SPONSORED PROJECT NO. V257006
GRANT NO. O EG-0-72-1868



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THREAD FORM - ISO METRIC AND ISO INCH SERIES





COMPARISON OF COMMON THREAD SIZES

ISO METRIC THREAD

COARSE THREAD SERIES



M 10 x 1.5 - 6g

THREAD SYMBOL FOR ISO

NOMINAL SIZE IN MILLIMETRES

PITCH IN MILLIMETRES

THREAD TOLERANCE CLASS SYMBOL

NOTE -

THE METRIC THREAD ILLUSTRATED IS A LITTLE LARGER IN DIAMETER THAN 3/8" AND HAS ALMOST 17 THREADS PER INCH.

UNIFIED NATIONAL

COARSE THREAD SERIES



3/8 - 16 UNC - 2A

MAJOR DIA

THREADS PER INCH

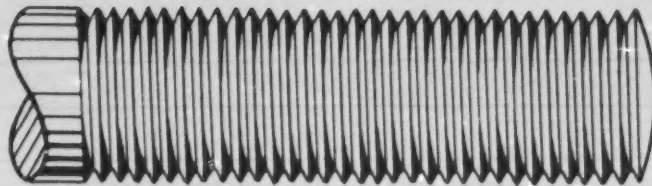
THREAD SERIES

CLASS

24 x 3	1-8
20 x 2.5	7/8-9
16 x 2	3/4-10
12 x 1.75	5/8-11
10 x 1.5	9/16-12
8 x 1.25	1/2-13
6 x 1	7/16-14
5 x .8	3/8-16
4 x .7	5/16-18
3 x .5	1/4-20
2.5 x .45	12-24
2 x .4	10-24
	8-32
	6-32
	5-40
	4-40
	3-48
	2-56

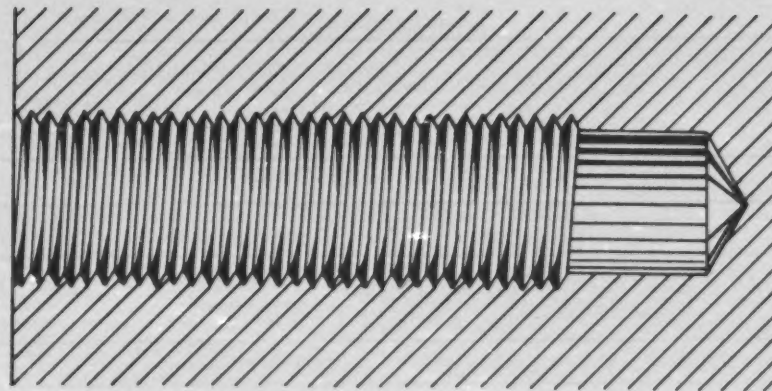


THREADS : EXTERNAL



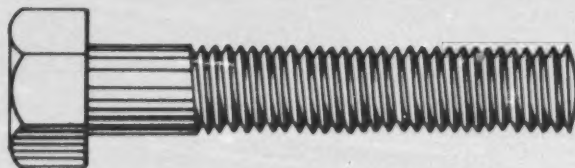
M 12 X 1.75 — 6g

INTERNAL



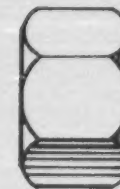
M 12 X 1.75 — 6H

SCREWS & BOLTS



M 12 — 6g

NUTS



M 12 — 6H

CLASS OF FIT	TOLERANCE CLASS	
	Bolts & Screws	Nuts
Medium	6g	6H



ISO METRIC THREAD FORM

P = PITCH in mm

$H = 0.86603P$

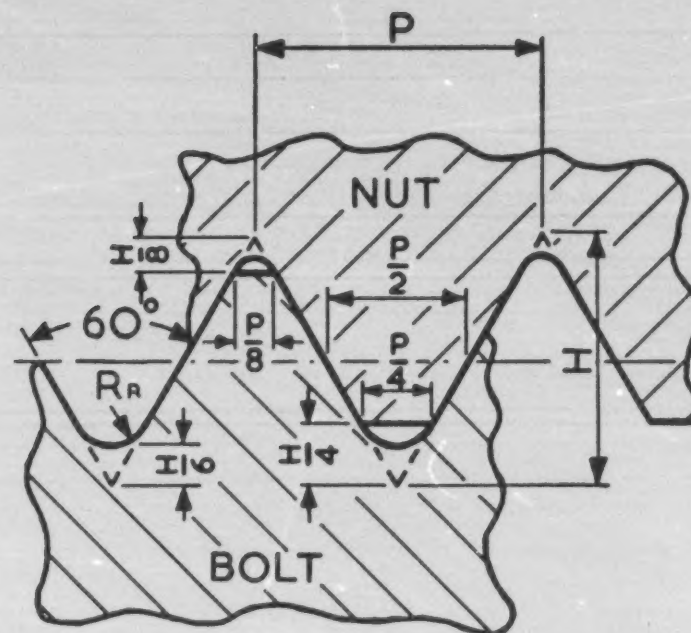
$\frac{H}{4} = 0.21651P$

$\frac{H}{6} = 0.14434P$ $\frac{H}{8} = 0.10825P$

$R_R = 0.14434P$

Depth
of thread in screw = $\frac{17}{24} H = 0.61343P$

Depth
of thread in nut = $\frac{5}{8} H = 0.54127P$

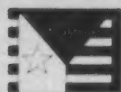




ISO Metric Thread—Coarse Series

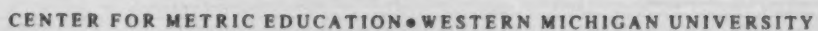
Diameter	2	2.5	3	4	5	6	8	10
Pitch	0.4	0.45	0.5	0.7	0.8	1.0	1.25	1.5
Basic effective diameter ...	1.740	2.208	2.675	3.545	4.480	5.350	7.188	9.026
Depth of thread in screw	0.25	0.28	0.31	0.43	0.49	0.61	0.77	0.92
Area of Root dia. (mm ²) ...	1.79	2.98	4.47	7.75	12.7	17.9	32.8	52.3
Diameter of tapping drill	1.6	2.05	2.5	3.3	4.2	5.0	6.8	8.5

Diameter	12	16	20	24	30	36	42	48
Pitch	1.75	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Basic effective diameter ...	10.863	14.701	18.376	22.051	27.727	33.402	39.077	44.752
Depth of thread in screw	1.07	1.23	1.53	1.84	2.15	2.45	2.76	3.07
Area of Root dia. (mm ²) ...	76.2	144	225	324	519	759	1050	1380
Diameter of tapping drill	10.2	14.0	17.5	21.0	26.5	32.0	37.5	43.0

**ISO Metric Thread—Fine Series**

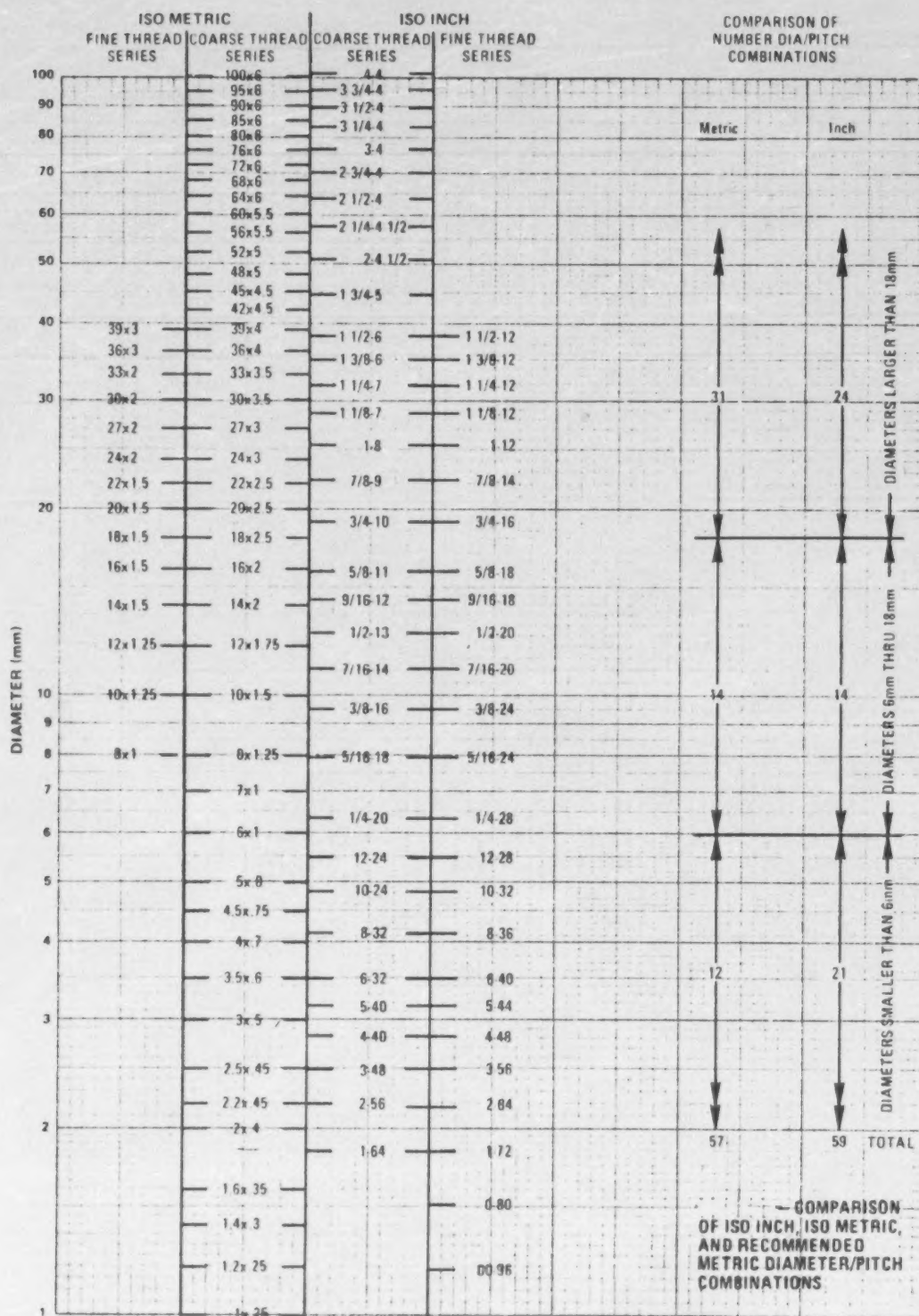
Diameter	8	10	12	14	16	18	20
Pitch	1.0	1.25	1.25	1.5	1.5	1.5	1.5
Basic effective dia. ...	7.350	9.188	11.188	13.026	15.026	17.026	19.026
Depth of thread in screw	0.61	0.77	0.77	0.92	0.92	0.92	0.92
Area of Root dia. (mm ²) ...	36.0	56.3	86.0	116	157	205	259
Diameter of tapping drill	7.0	8.8	10.8	12.5	14.5	16.5	18.5

Diameter	22	24	30	36	42	48
Pitch	1.5	2.0	2.0	3.0	3.0	3.0
Basic effective diameter ...	21.026	22.701	28.701	34.051	40.051	46.051
Depth of thread in screw	0.92	1.23	1.23	1.84	1.84	1.84
Area of Root dia. (mm ²) ...	319	365	586	820	1210	1540
Diameter of tapping drill	20.5	22.0	28.0	33.0	39.0	45.0





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USOE SPONSORED PROJECT NO. V257006
GRANT NO. O EG-0-72-1868

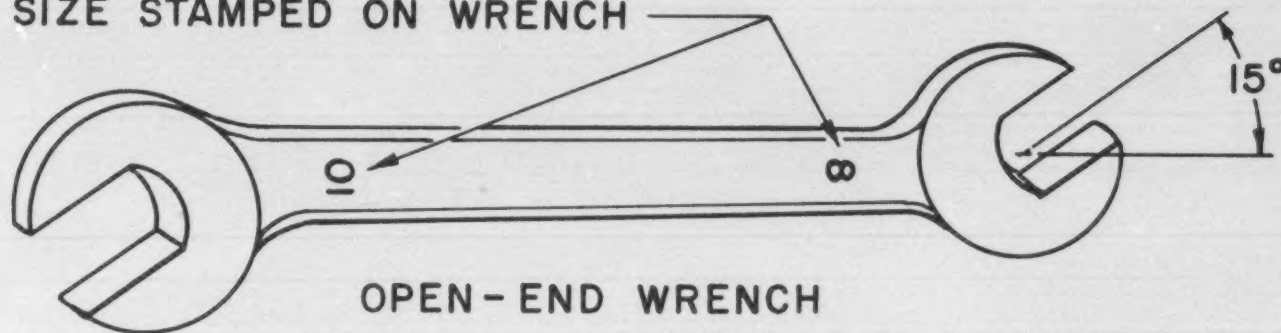
RECOMMENDED
METRIC DIA/PITCH
SERIES

	100x6	
	90x6	<u>Recommended</u>
	80x6	
	72x6	
	64x6	
	56x5.5	
	48x5	
	42x4.5	
	36x4	
	30x3.5	12
	25x3	
	20x2.5	
	16x2	
	12.5x1.75	
	10x1.5	5
	8x1.25	
	6.3x1	
	5x.9	
	4x.8	
	3.15x.65	
	2.5x.55	
	2x.45	
	1.6x.35	25
	1.25x.3	
	1x.25	



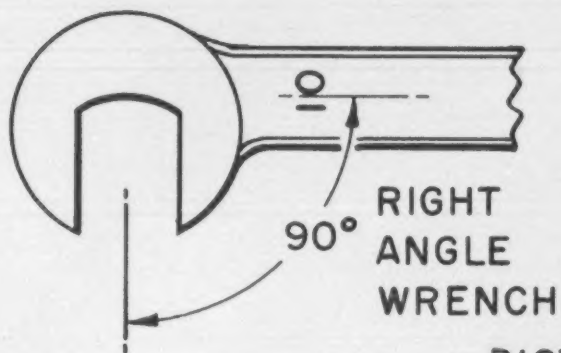


SIZE STAMPED ON WRENCH

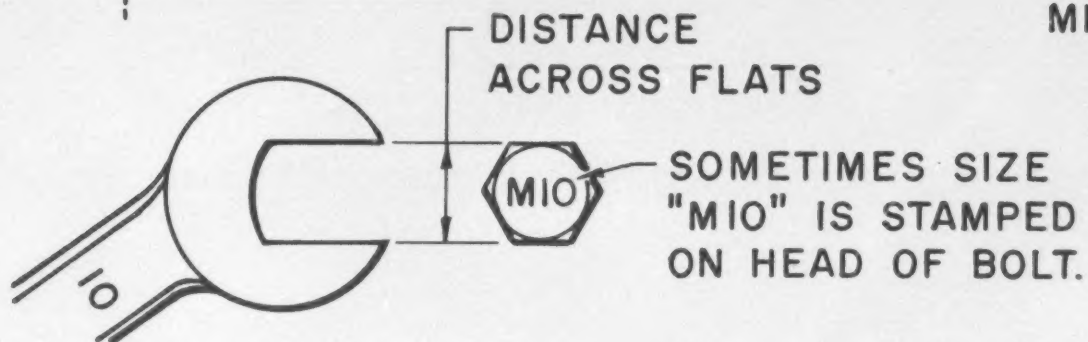


OPEN-END WRENCH

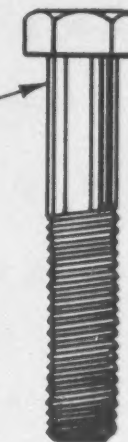
MIO METRIC WRENCH FOR MIO BOLT.
(DO NOT CONFUSE WITH INCH SIZE
WRENCHES. 10mm IS BETWEEN A 3/8"
AND 7/16" WRENCH IN SIZE.)



90°
RIGHT
ANGLE
WRENCH



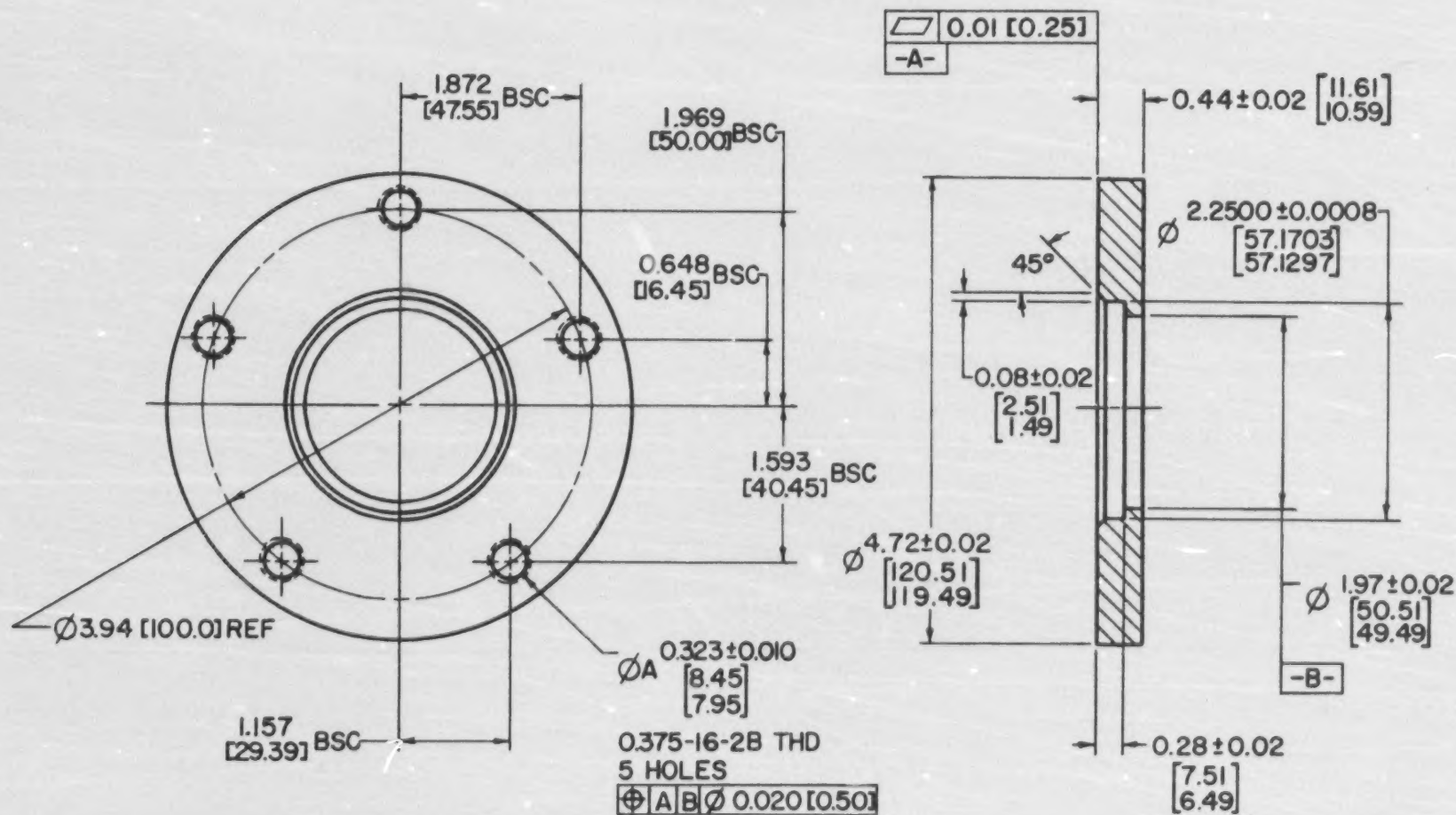
MIO x 1.5



SOMETIMES SIZE
"MIO" IS STAMPED
ON HEAD OF BOLT.



DUAL DIMENSIONING

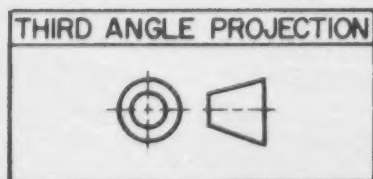
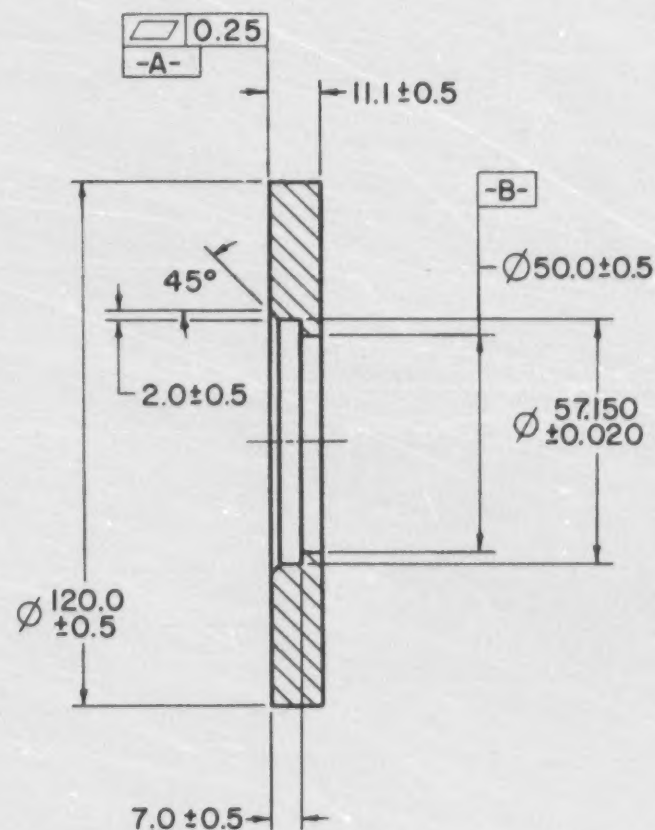
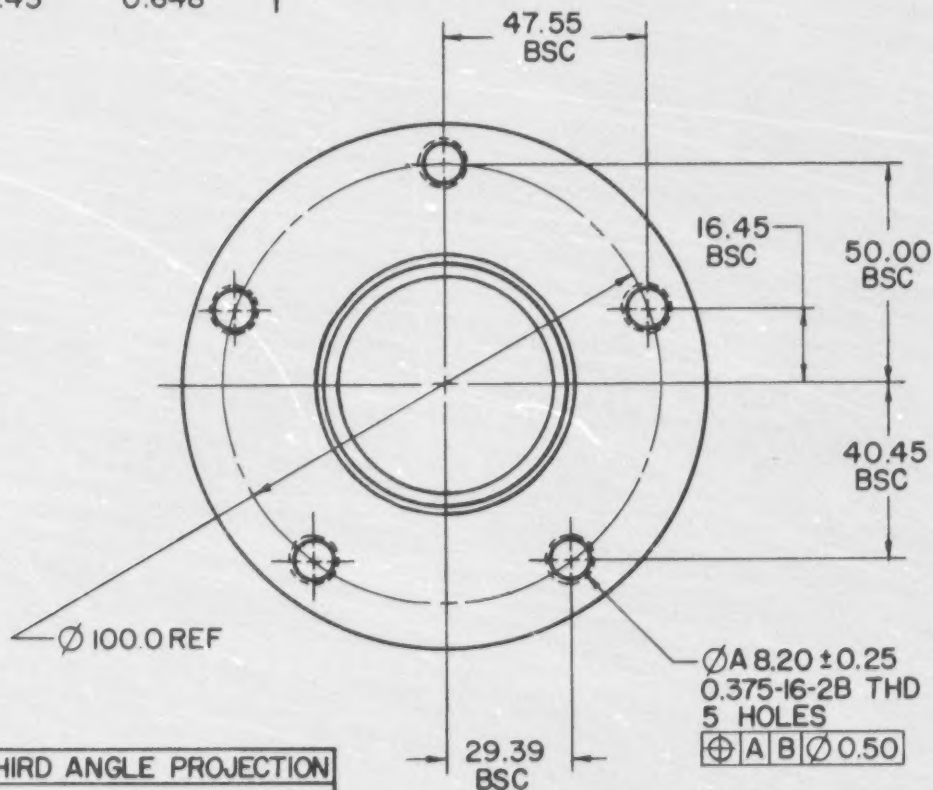




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MASTER DIMENSIONING (WITH CUSTOMARY READOUT CHART)

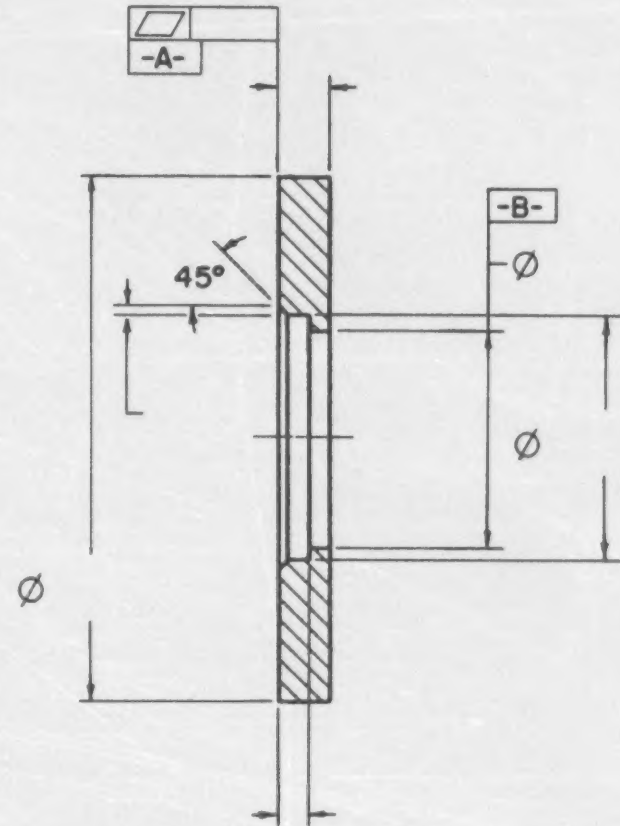
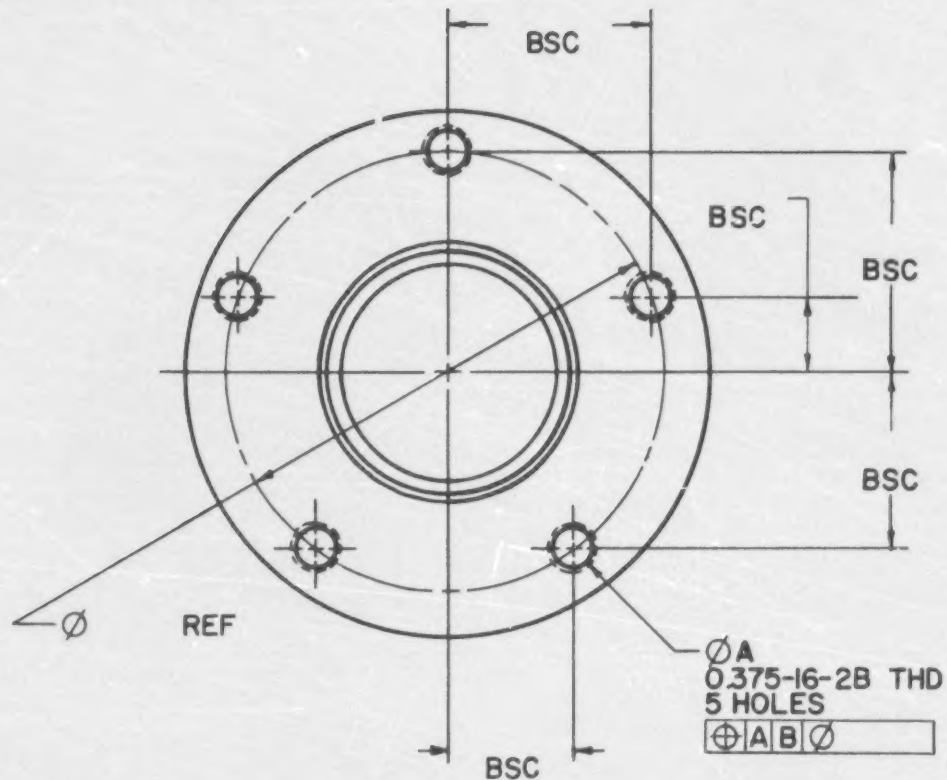
CONVERSION			
mm	inch	mm	inch
0.020	0.0008	29.39	1.157
0.25	0.010	40.45	1.593
0.5	0.02	47.55	1.872
0.50	0.020	50.0	1.97
2.0	0.08	50.00	1.969
7.0	0.28	57.150	2.2500
8.20	0.323	100.0	3.94
11.1	0.44	120.0	4.72
16.45	0.648		



UNLESS OTHERWISE SPECIFIED:
±1° TOL ON ANGULAR DIM.
FINISH ALL OVER



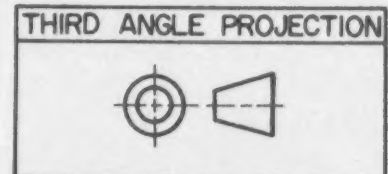
MASTER UNIDIMENSIONING



271

272

UNLESS OTHERWISE SPECIFIED:
±1° TOL ON ANGULAR DIM.
FINISH ALL OVER



METRIC

47.55

0.25

11.1 ± 0.5

16.45

50.0 ± 0.5

50.00

2.0 ± 0.5

57.150
± 0.020

40.45

120.0
± 0.5

100.0

820 ± 0.25

29.39

0.50

7.0 ± 0.5

273

274

+

+

CUSTOMARY

0.01

1.872

0.44 ± 0.02

0.648

1.97 ± 0.02

1.969

0.08 ± 0.02

2.2500 ± 0.0008

1.593

4.72 ± 0.02

3.94

0.323 ± 0.010

1.157

0.020

0.28 ± 0.02

275

276

+

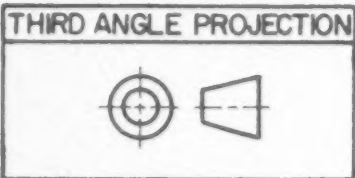
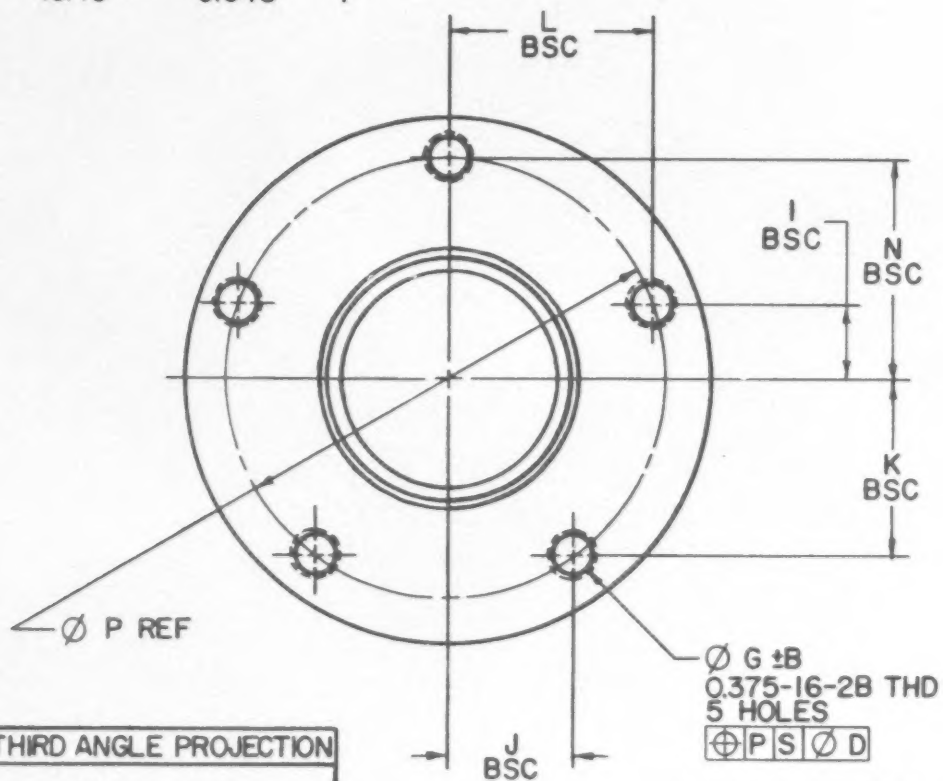
+



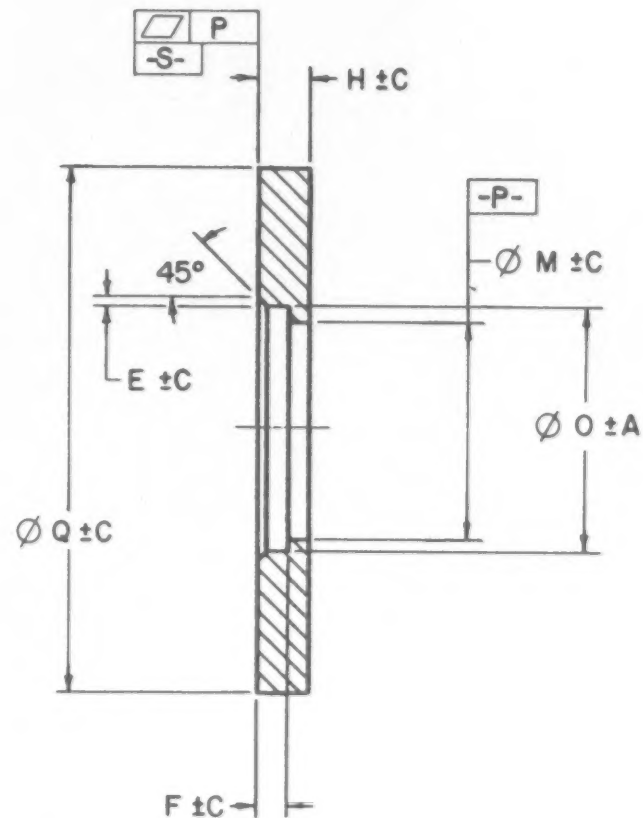
IDENTIFICATION LETTER DIMENSIONING

CONVERSION

	mm	inch		mm	inch
A	0.020	0.0008	J	29.39	1.157
B	0.25	0.010	K	40.45	1.593
C	0.5	0.02	L	47.55	1.872
D	0.50	0.020	M	50.0	1.97
E	2.0	0.08	N	50.00	1.969
F	7.0	0.28	O	57.150	2.2500
G	8.20	0.323	Q	100.0	3.94
H	11.1	0.44	R	120.0	4.72
I	16.45	0.648			



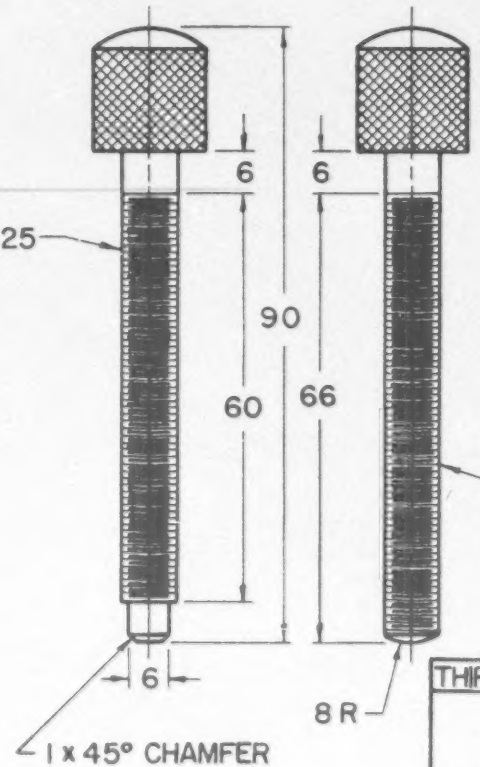
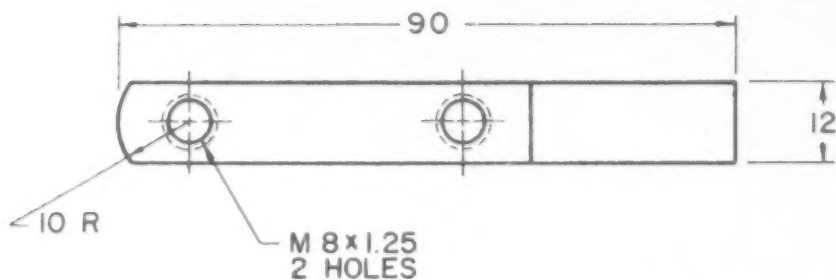
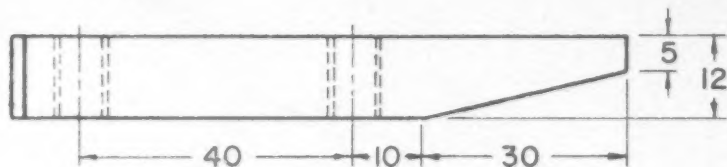
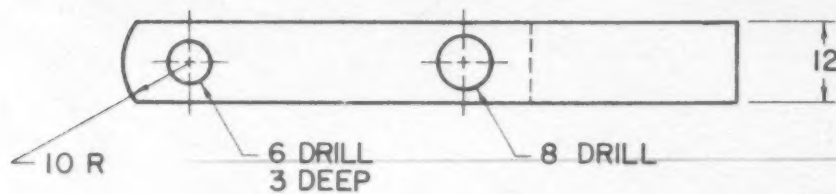
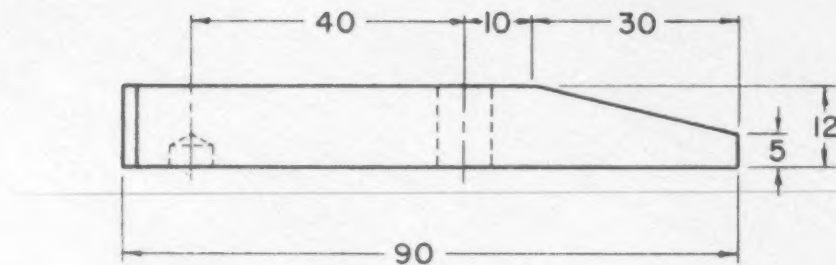
UNLESS OTHERWISE SPECIFIED:
±1° TOL ON ANGULAR DIM.
FINISH ALL OVER



DATUM SURFACES:
P = PRIMARY
S = SECONDARY



METRIC DRAWING - METALWORKING (TOOLMAKER'S CLAMP)



CONVERSION CHART

mm	inch
1	0.039
3	0.118
5	0.197
6	0.236
8	0.315
10	0.394
12	0.472
16	0.630
30	1.181
40	1.575
60	2.362
66	2.598
90	3.543

ISO METRIC
THREAD
M 8 x 1.25

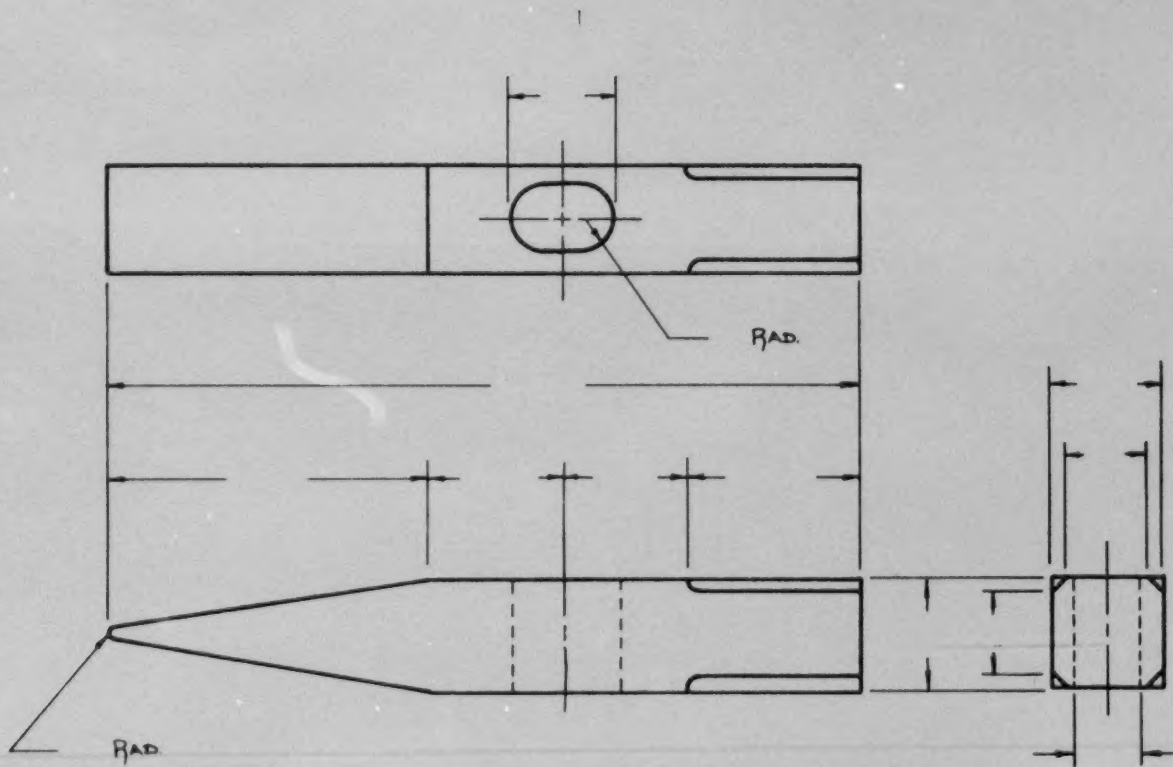
UNC THREAD
5/16-18-UNC

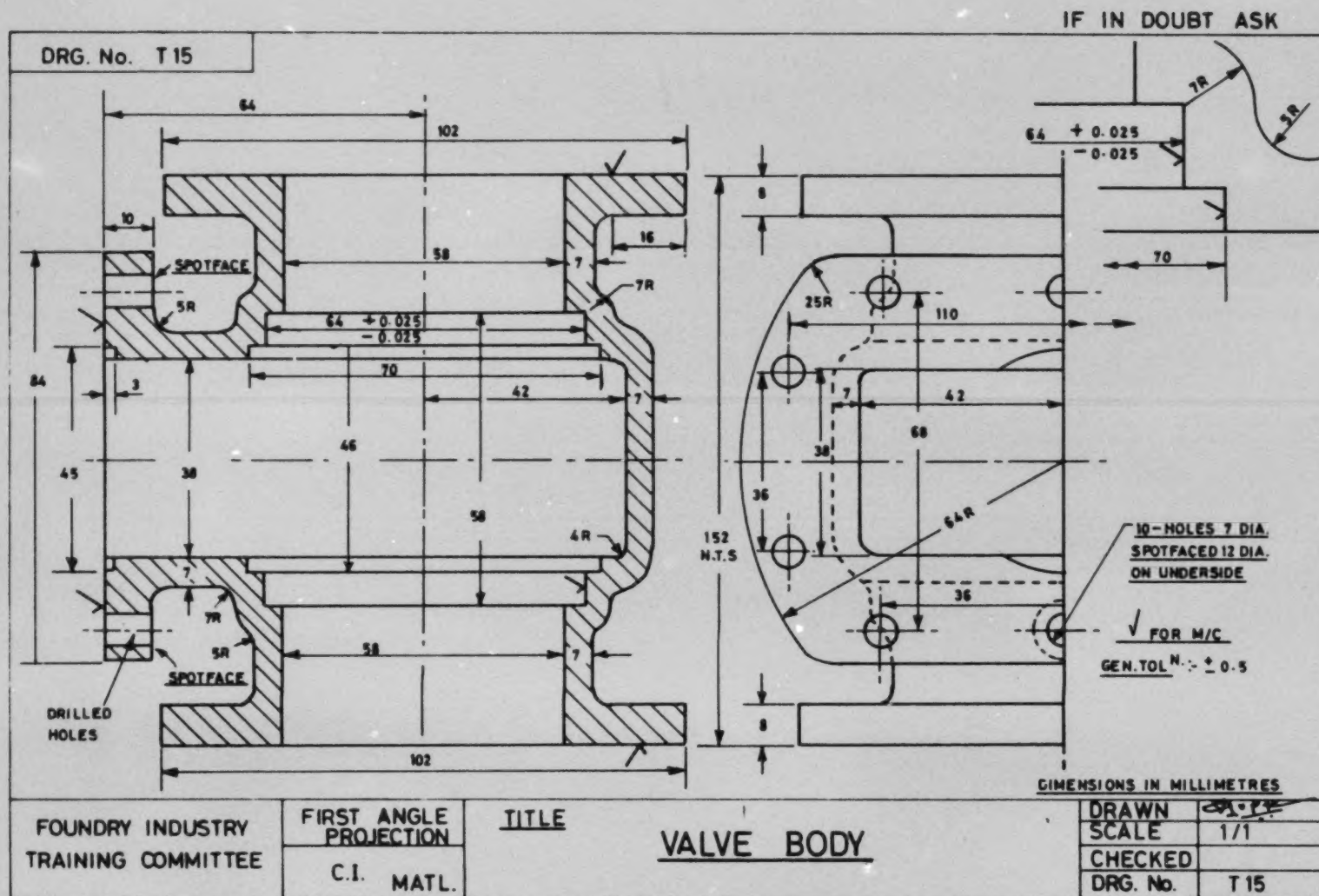
THIRD ANGLE PROJECTION

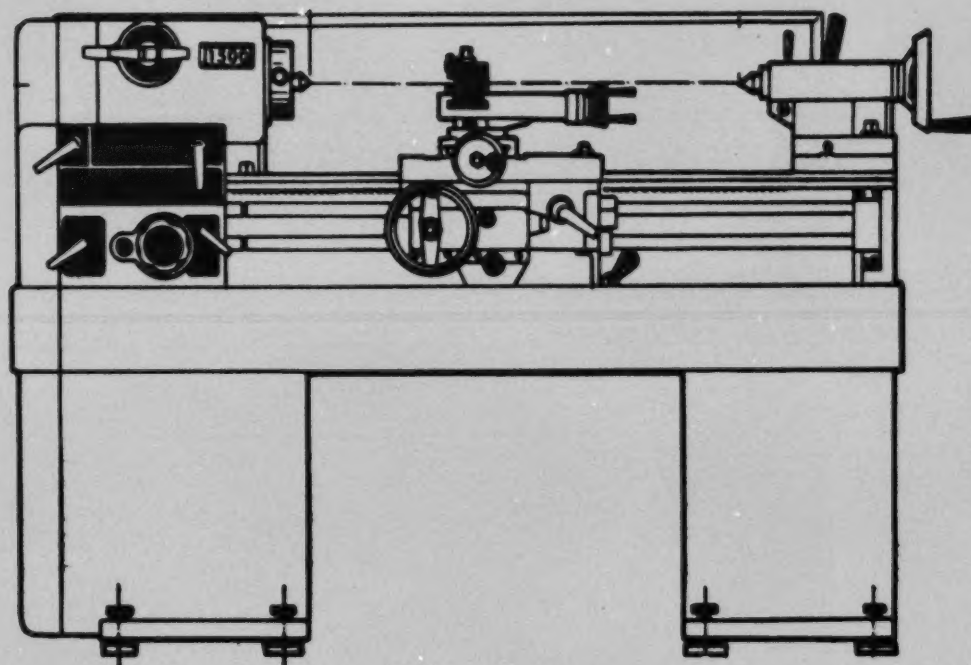


Metric Dimensioning

The drawing shown below is of a common riveting hammer-head found in most school shops. You are to measure the dimensions of the hammer and place them at the proper locations. Use your metric scale. All dimensions are in millimetres.







+

+

THREAD CUTTING
NEED METRIC THREADING ATTACHMENT - COMPLETE
WITH GEARS, QUADRANT BRACKET, QUADRANT,
SPACERS, STUDS AND GEAR CHART.

FEED RATE
INDICATOR

DUAL READING DIALS -
CUSTOMARY & METRIC

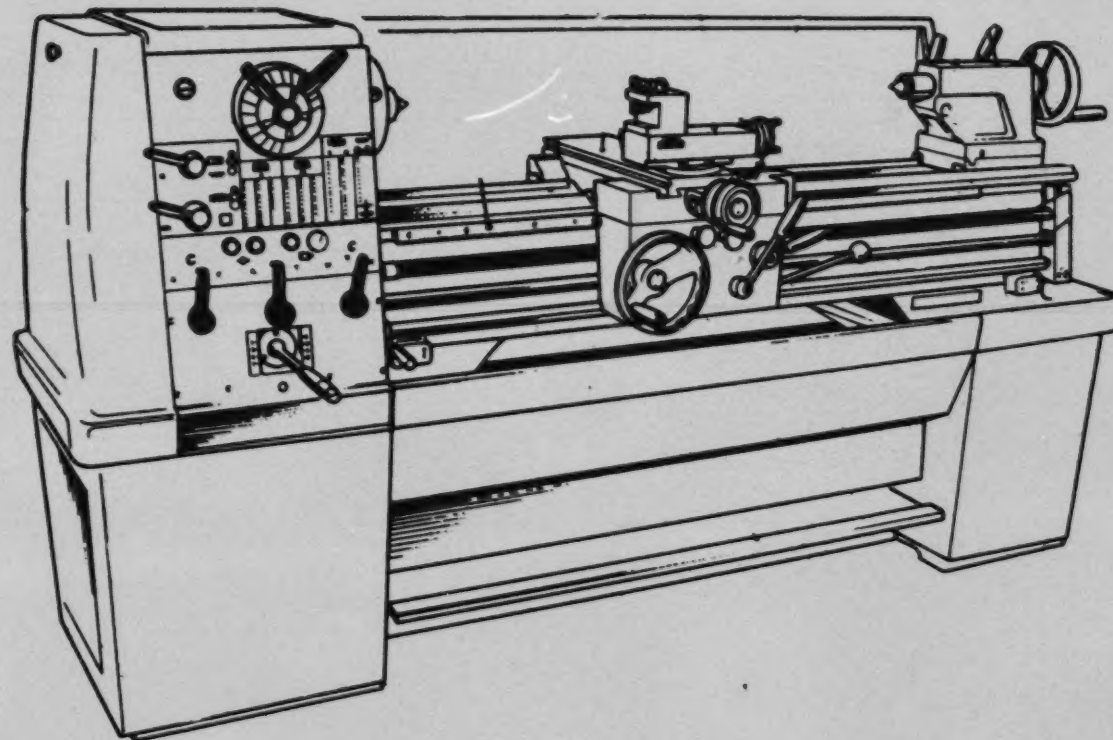
CHANGES FOR METRIC CONVERSION

285

286

+

+



287

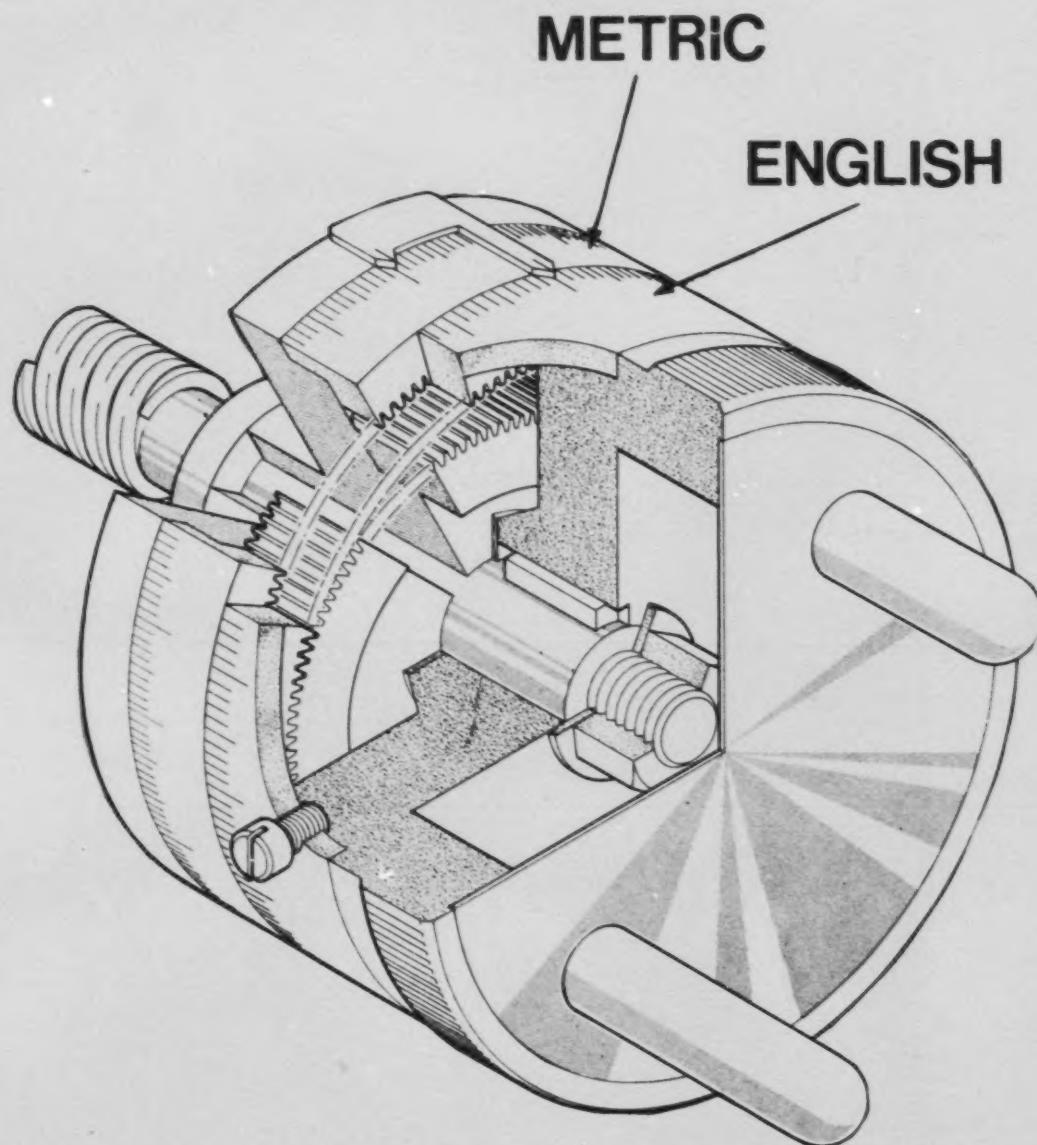
288

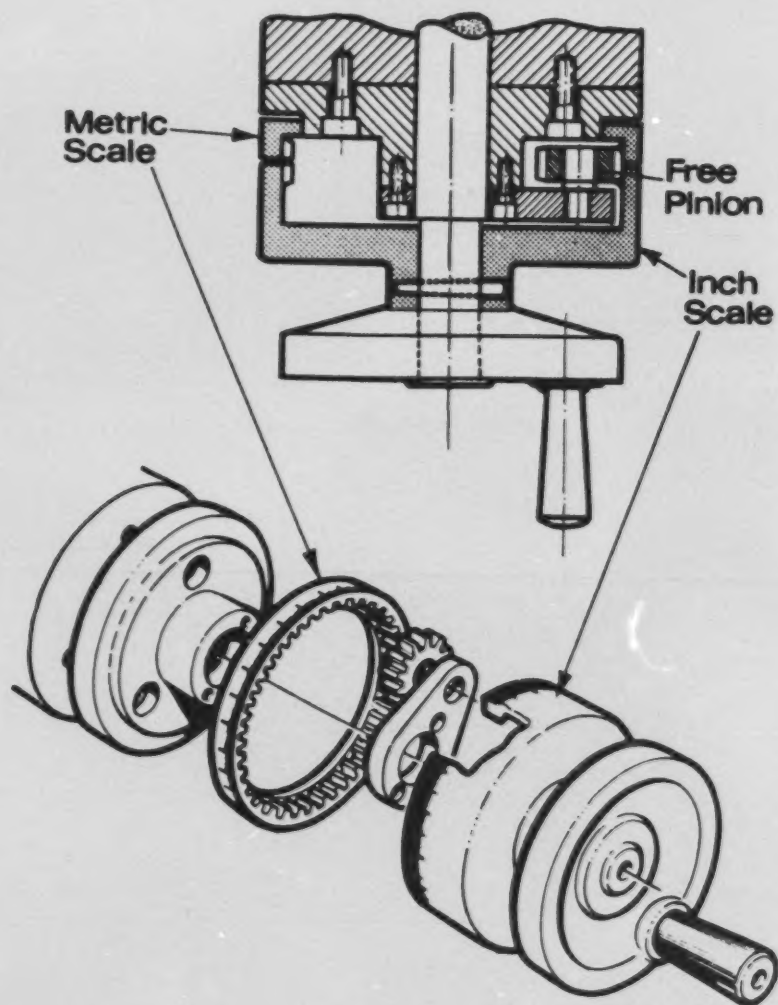
+

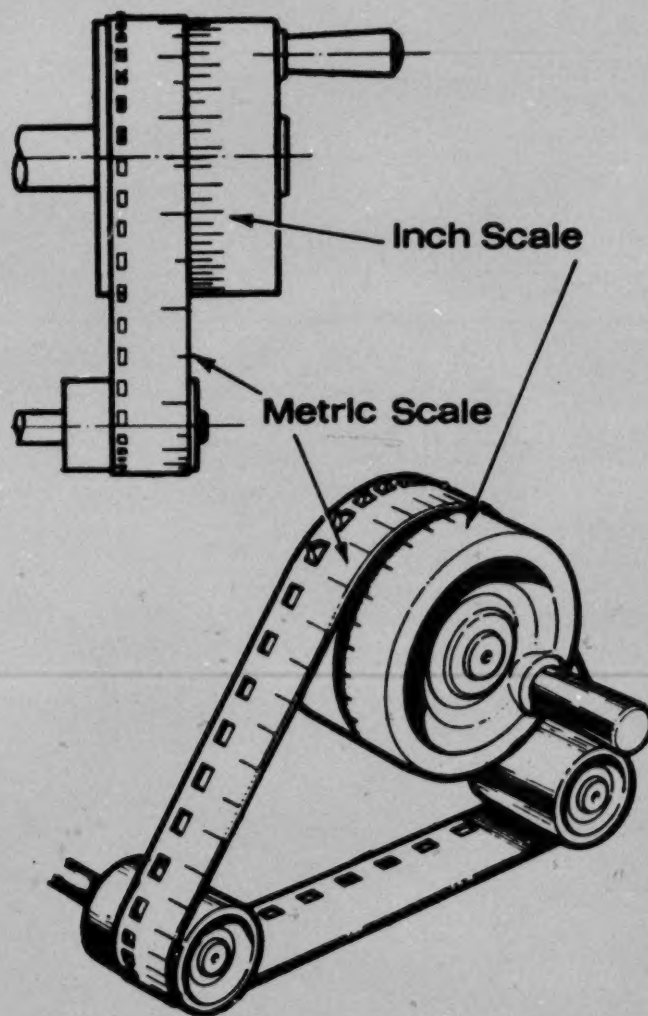
THREAD CUTTING (No change)
Unified (ISO inch)
and ISO metric
available on
QUICK CHANGE
GEAR BOX

FEED RATE
INDICATOR

DUAL READING DIALS -
CUSTOMARY & METRIC



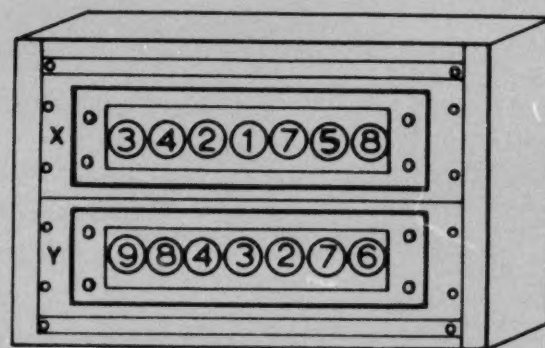






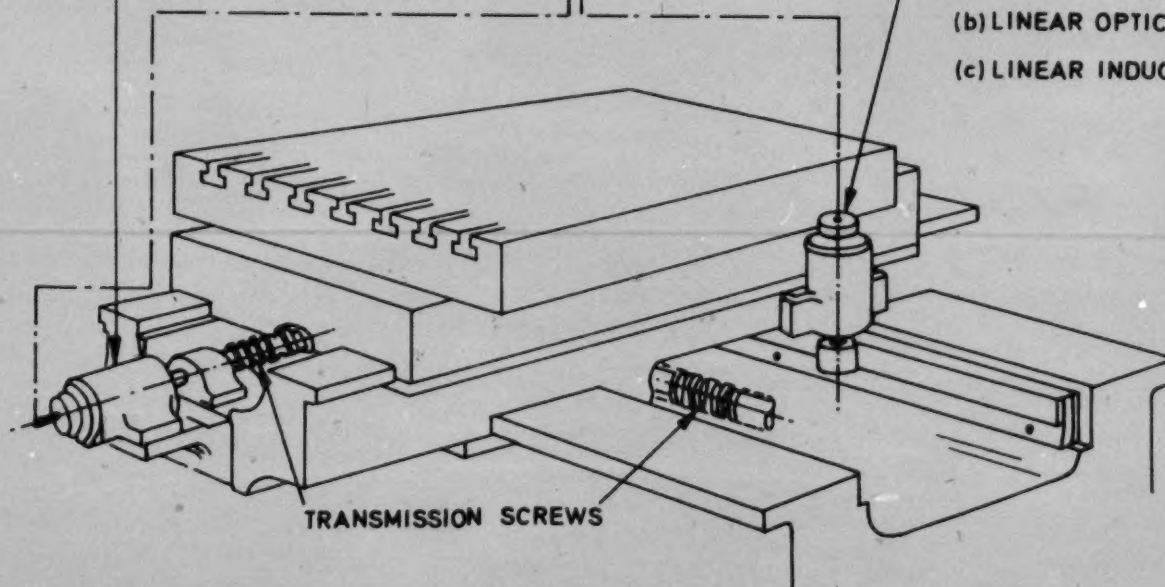
TYPES WHICH CAN BE
DIRECTLY COUPLED TO
THE TRANSMISSION INCLUDE:-

- (a) MAGNETIC RESOLVER
- (b) OPTICAL DIGITISER
- (c) ELECTRICAL DIGITISER
- (d) ROTARY INDUCTOSYN



TYPES WHICH CAN BE INDEPENDENT
OF THE TRANSMISSION INCLUDE:-

- (a) ROTARY TRANSDUCER DRIVEN BY
RACK & PINION, ROLLER & BEAM
OR RECIRCULATING BALL SCREW
& NUT
- (b) LINEAR OPTICAL GRATING
- (c) LINEAR INDUCTOSYN





Temperatures, Steel Colors, and Related Processes

	Colors	F	°C	Processes
Heat Colors	White	2500° 2400°	1371° 1315°	Welding
	Yellow-White	2300° 2200° 2100°	1259° 1204° 1149°	
	Yellow	2000° 1900°	1093° 1036°	High speed steel hardening (1177-1343°C)
	Orange-Red	1800° 1700°	981° 926°	
	Light cherry red	1600° 1500°	871° 815°	
	Cherry red	1400° 1300°	760° 704°	
	Dark red	1200° 1100°	648° 593°	Alloy tool steel hardening (816-1066°C)
	Very dark red	1000° 900° 800°	538° 482° 426°	
	Black red in dull light or darkness	700°	371°	
	Pale blue (310°C)	600°	315°	
Temper Colors	Violet (285°C)	500°	260°	Carbon tool steel hardening (732-843°C)
	Purple (274°C)	400°	204°	
	Yellowish-Brown (254°C)	300°	149°	High speed steel tempering (538-593°C)
	Dark straw (241°C)	300°	149°	
	Light straw (218°C)	200° 100° 0°	93° 38° 18°	
				Carbon tool steel tempering (149-566°C)

GOING METRIC IN GRAPHIC ARTS -- NOTES AND COMMENTS

For more detailed information on this series, obtain the following reference:

Going Metric with the U.S. Printing Industry by Clive A. Cameron,
Available from: Graphic Arts Research Center
Rochester Institute of Technology
Rochester, NY 14623
1972 edition
cost - \$4.50

1. ISO - A SIZE PAPER. A graphic representation of the effect of doubling or halving the size of the area. Any size in the series can be obtained by enlargement or reduction and it will always retain the proportion of $1:\sqrt{2}$. The basic size of A0, from which all other sizes follow, equals one square metre (m^2).
2. COMPARING $8\frac{1}{2} \times 11$ TO ISO A4 SIZE PAPER. Commercial standard letterhead is now $8\frac{1}{2} \times 11$. The standard government letterhead is $8 \times 10\frac{1}{2}$. The A4 size could standardize the size throughout the country. All Canadian government activities use the A4 size.
3. RELATIONSHIP BETWEEN A, B, AND C SIZE PAPER. A, B, and C sheets retain the same relationship in all sizes.
4. COMPARISON CHART - A SIZE PAPER. The "A" series size paper applies to general printed matter, including stationery and publications. These sizes are trimmed sizes.
5. STOCK SIZES - FOR A SERIES PAPER. All "A" size paper can be cut from the "A" stock sizes.
6. R20 SERIES OF PAPER WEIGHTS AND EQUIVALENT WEIGHTS. The "R" series is based on a formula of geometric progression. R20 measurements are based on the 20th root of 10 ($^{20}\sqrt{10}$).

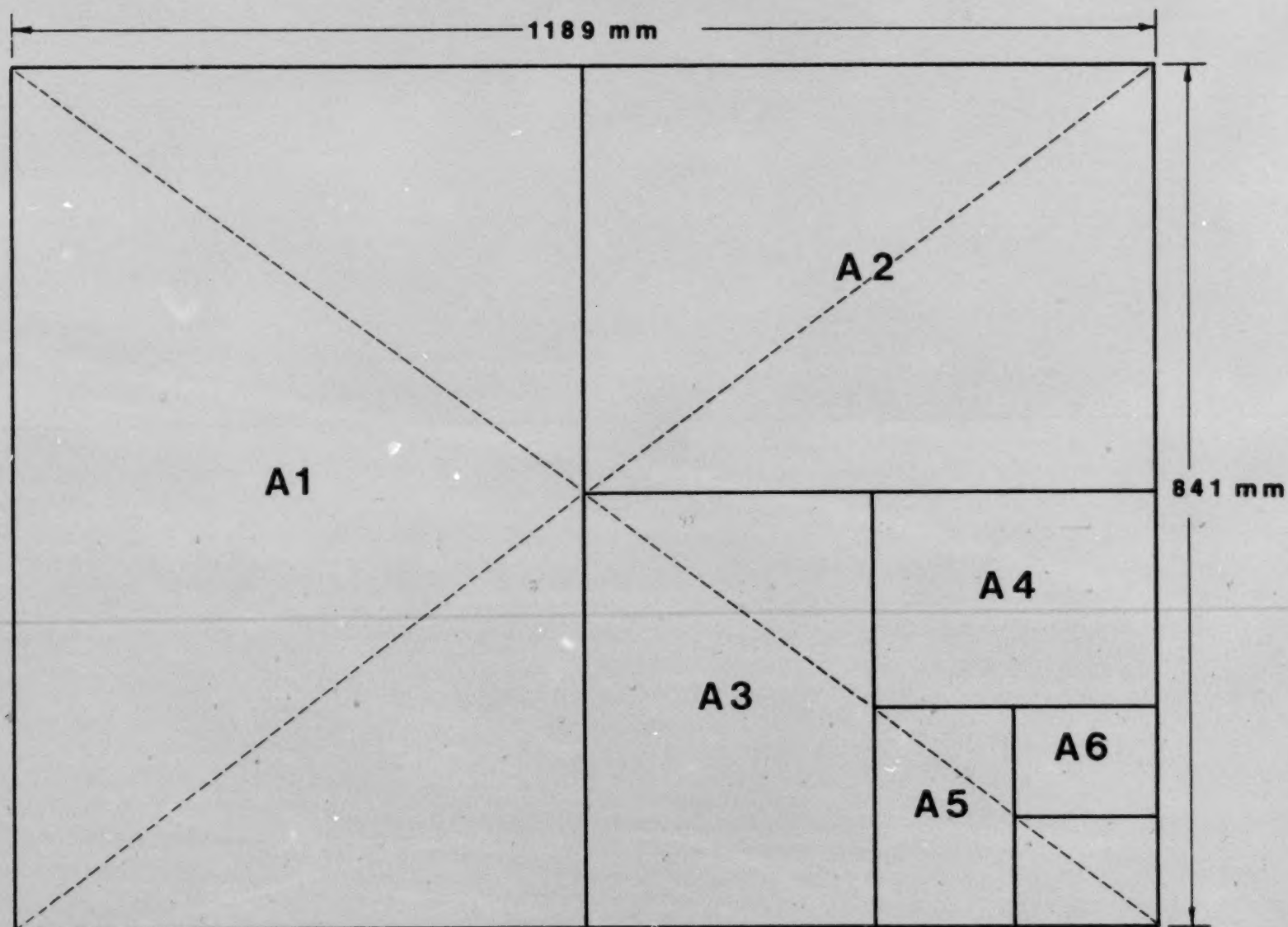
Thus, each basis weight in the R20 series is obtained by multiplying the previous one by the 20th root of 10, or 1.12.

7. COMPARISON CHART - B SIZE PAPER. The "B" series normally intended for the posters or other printed items, such as wall charts, where the difference in size of the larger sheets in the "A" series represents too large a jump.
8. COMPARISON CHART - C SIZE ENVELOPE. The "C" series is used for folders, postcards, and most conveniently for envelopes. The "C" series of envelope sizes is suitable for insertion of "A" series sheets either flat or folded.
9. COMPARING C4 ENVELOPE TO A4 AND A3 SIZE PAPER. no comment
10. COMPARING C5 ENVELOPE TO A4 AND A5 SIZE PAPER. no comment
11. COMPARING C6 ENVELOPE TO A4 AND A5 SIZE PAPER. no comment
12. COMPARING DL ENVELOPE TO A4 AND A5 SIZE PAPER. The DL envelope is a special envelope used to take the place of the regular business envelope.
13. PRINTER'S UNITS - CUSTOMARY & METRIC EQUIVALENTS. no comment
14. METRIC UNITS - PRINTER'S & CUSTOMARY EQUIVALENTS. no comment
15. SCREEN RULINGS. No change in screen rulings would take place. ISO standards are usually in millimetres rather than centimetre measurement. The use of centimetres would appear to be more suitable in this instance.

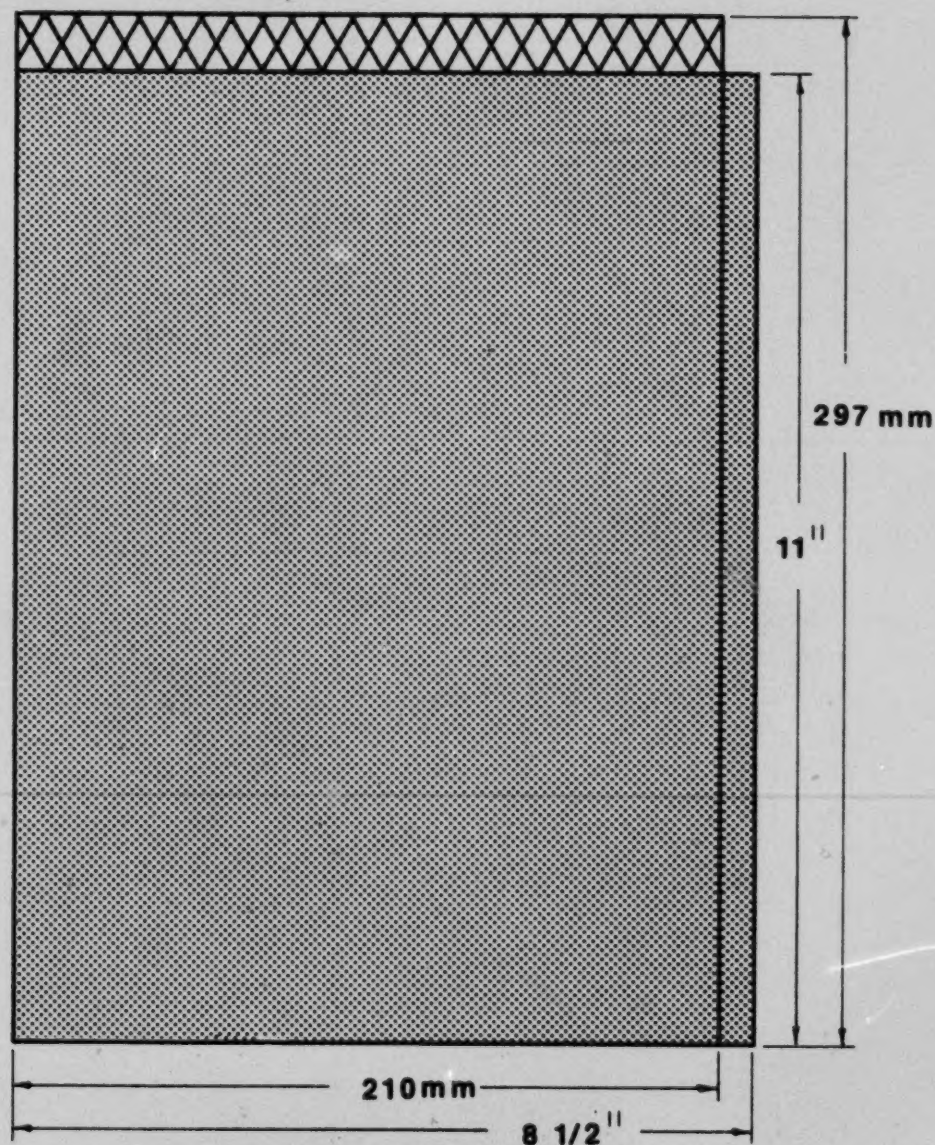


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ISO - A SIZE PAPER



300



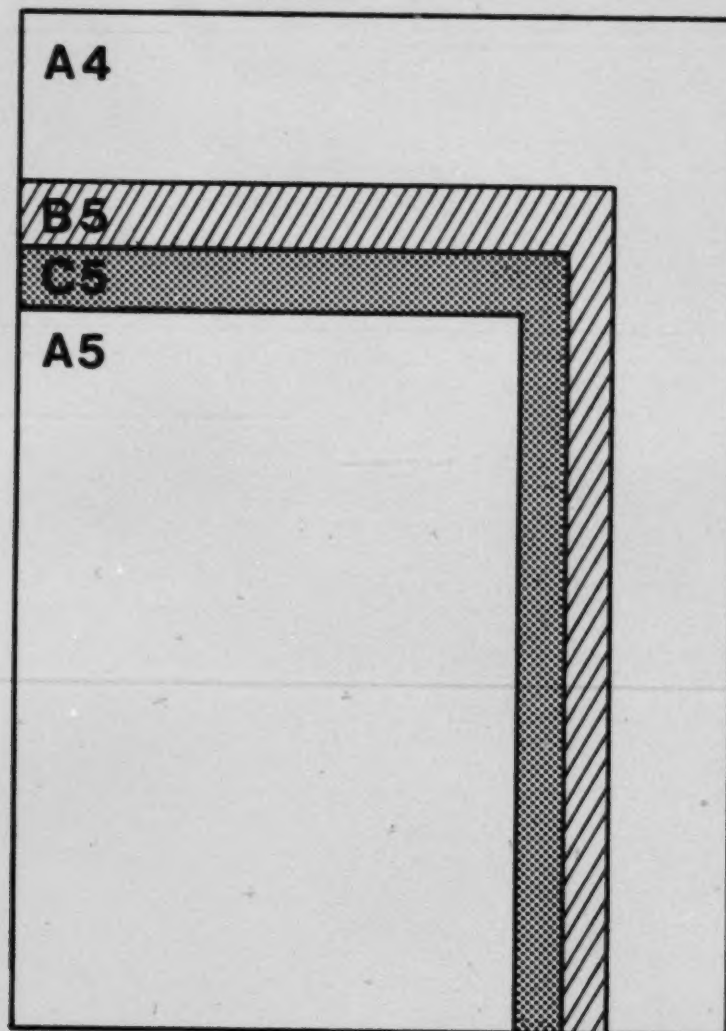
301

302

COMPARING 8 1/2 x 11 TO ISO A4 SIZE PAPER



RELATIONSHIP BETWEEN A, B, AND C SIZE PAPER



303

304



COMPARISON CHART - A SIZE PAPER

ISO-sizes	METRIC-millimetres	CUSTOMARY-inches
2A	1189 x 1682	46.81 x 66.22
A0	841 x 1189	33.11 x 46.81
A1	594 x 841	23.39 x 33.11
A2	420 x 594	16.54 x 23.39
A3	297 x 420	11.69 x 16.54
A4	210 x 297	8.27 x 11.69
A5	148 x 210	5.83 x 8.27
A6	105 x 148	4.13 x 5.83
A7	74 x 105	2.91 x 4.13
A8	52 x 74	2.05 x 2.91
A9	37 x 52	1.46 x 2.05
A10	26 x 37	1.02 x 1.46



STOCK SIZES - FOR A SERIES PAPER

Sizes for Normal Trims

ISO - size	METRIC - millimetres	CUSTOMARY - inches
RAO	860 x 1220	33.86 x 48.03
RA1	610 x 860	24.02 x 33.86
RA2	430 x 610	16.93 x 24.02

Sizes for Bleed Work or Extra Trims

ISO - size	METRIC - millimetres	CUSTOMARY - inches
SRAO	900 x 1280	35.43 x 50.39
SRA1	640 x 900	25.20 x 35.43
SRA2	450 x 640	17.72 x 25.20

**R20 SERIES OF PAPER WEIGHTS AND EQUIVALENT WEIGHTS**

<i>'R' series</i>	<i>Bond</i>	<i>Cover</i>	<i>Index</i>	<i>Newsprint</i>	<i>Book</i>
	17 x 22	20 x 26	25½ x 30½	24 x 36	25 x 38
	432 x	508 x	648 x	610 x	635 x
	559 mm	660 mm	775 mm	914 mm	965 mm
<i>g/m²</i>	<i>lb/ream</i>	<i>lb/ream</i>	<i>lb/ream</i>	<i>lb/ream</i>	<i>lb/ream</i>
20.0	5.32	7.39	11.00	12.29	13.51
22.4	5.95	8.28	12.39	13.77	15.13
25.0	6.65	9.24	13.83	15.36	16.89
28.0	7.44	10.35	15.49	17.21	18.92
31.5	8.37	11.65	17.43	19.36	21.28
45.0	11.97	16.64	24.89	27.66	30.40
50.0	13.30	18.49	27.66	30.73	33.78
56.0	14.89	20.71	30.98	34.42	37.84
63.0	16.75	23.30	34.85	38.72	42.57
71.0	18.88	26.26	39.28	43.63	47.97
85.0	22.61	31.45	46.90	52.27	57.46
100.0	26.60	36.98	55.32	61.46	67.57
112.0	29.79	41.42	61.96	68.83	75.68
140.0	37.24	51.78	77.45	86.04	94.60
180.0	47.88	66.57	99.58	110.62	121.63
200.0	53.20	73.97	110.64	122.91	135.14
250.0	66.50	92.46	138.30	153.64	168.93
400.0	106.41	147.95	221.29	245.83	270.29



COMPARISON CHART - B SIZE PAPER

ISO-sizes	METRIC-millimetres	CUSTOMARY-Inches
B0	1000 x 1414	39.37 x 55.67
B1	707 x 1000	27.83 x 39.37
B2	500 x 707	19.68 x 27.83
B3	353 x 500	13.90 x 19.68
B4	250 x 353	9.84 x 13.90
B5	176 x 250	6.93 x 9.84
B6	125 x 176	4.92 x 6.93
B7	88 x 125	3.46 x 4.92
B8	62 x 88	2.44 x 3.46
B9	44 x 62	1.73 x 2.44
B10	31 x 44	1.22 x 1.73



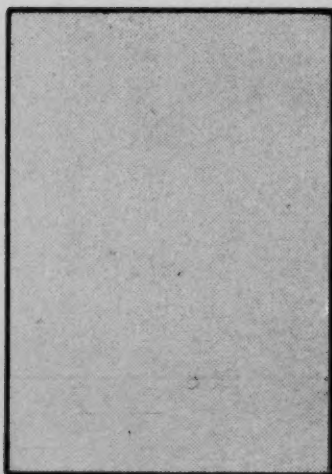
COMPARISON CHART - C SIZE ENVELOPE

ISO - size	METRIC - millimetres	CUSTOMARY - inches
C4	229 x 324	9.02 x 12.76
C5	162 x 229	6.38 x 9.02
C6	114 x 162	4.49 x 6.38
DL	110 x 220	4.33 x 8.66

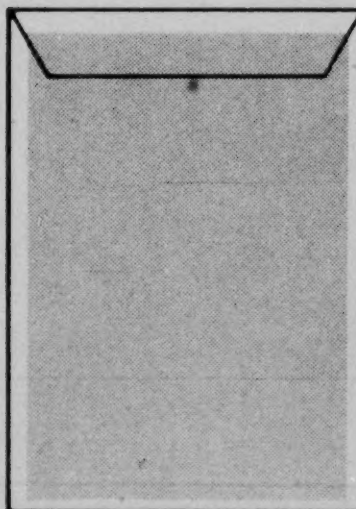


COMPARING C4 ENVELOPE TO A4 AND A3 SIZE PAPER

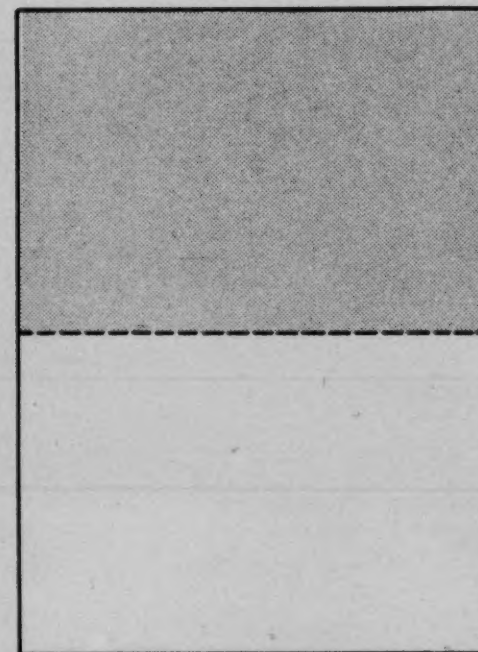
A4

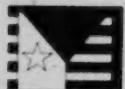


C4



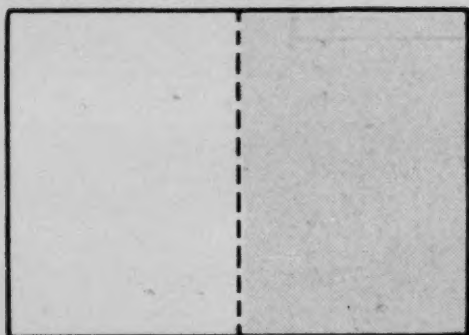
A3 FOLDED ONCE



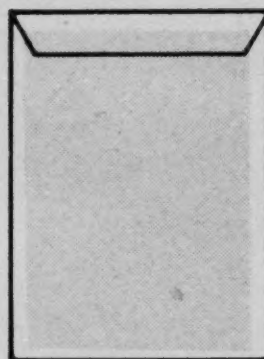


COMPARING C5 ENVELOPE TO A4 AND A5 SIZE PAPER

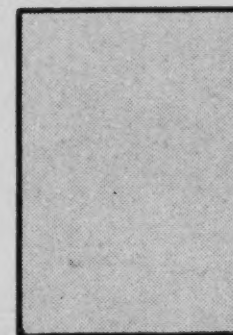
A4 FOLDED ONCE



C5



A5



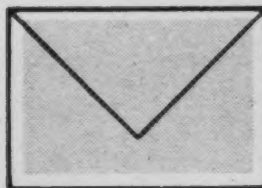


COMPARING C6 ENVELOPE TO A4 AND A5 SIZE PAPER

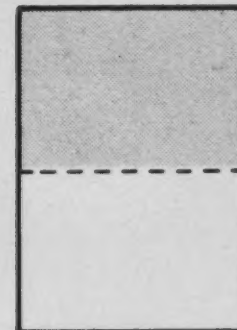
A4 FOLDED TWICE



C6



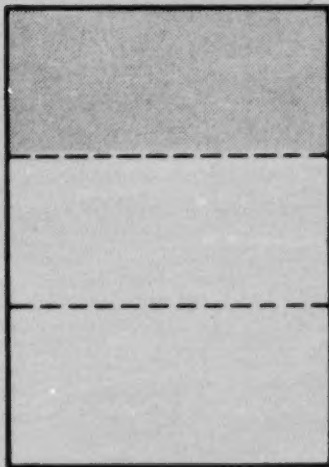
A5 FOLDED ONCE



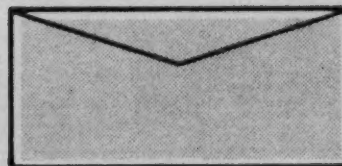


COMPARING DL ENVELOPE TO A4 AND A5 SIZE PAPER

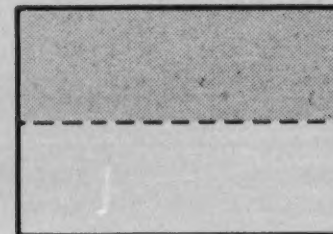
A4 FOLDED TWICE



DL



A5 FOLDED ONCE





PRINTER'S UNITS CUSTOMARY & METRIC EQUIVALENTS

PRINTER'S		CUSTOMARY—INCHES		METRIC—millimetres
Picas	Points	Approximate Fraction	Decimal	
	1	1/64	.014	.35
	2	1/32	.028	.70
	3	3/64	.042	1.05
	4	7/128	.055	1.40
	5	1/16	.069	1.75
	6	5/64	.083	2.10
	7	3/32	.097	2.45
	8	7/64	.111	2.80
	9	1/8	.125	3.15
	10	9/64	.138	3.50
1	12	21/128	.166	4.20
	14	25/128	.194	4.90
	18	1/4	.249	6.30
2	24	21/64	.332	8.40
	30	53/128	.414	10.50
3	36	1/2	.498	12.60
	42	37/64	.581	14.70
4	48	85/128	.664	16.80
5	60	53/64	.828	21.00
6	72	1	.996	25.20



METRIC UNITS PRINTER'S & CUSTOMARY EQUIVALENTS

METRIC-millimetres	PRINTER'S		CUSTOMARY-Inches
	Points	Approximate Picas + Points	
1	2.86		.039
2	5.71		.079
3	8.57		.118
4	11.43		.157
5	14.29	1 + 2¼	.197
6	17.14	1 + 5	.236
7	20.00	1 + 8	.276
8	22.86	1 + 10¼	.315
9	25.71	2 + 1½	.354
10	28.57	2 + 4½	.394
15	42.86	3 + 6¾	.591
20	57.14	4 + 9	.787
25	71.43	5 + 11	.984
30	85.71	7 + 1¼	1.181
35	100.00	8 + 3½	1.378
40	114.28	9 + 5¾	1.575
45	128.57	10 + 4	1.772
50	142.85	11 + 6¼	1.969
75	214.28	17 + 5¼	2.953
100	285.71	23 + 8½	3.937



SCREEN RULINGS

Customary Rulings
per inch

Metric Rulings
per centimetre

50	20
65	26
75	30
100	40
120	48
133	54
150	60
175	70
200	80

GOING METRIC IN WOODWORKING -- NOTES AND COMMENTS

1. MACHINE WOODWORK -- GAGE AND SCALE CONVERSION. Inasmuch as all woodworking machines are adjustable to depth and width of cut, it is unnecessary to consider any metric replacements. Instead, one can purchase pressure sensitive metric tape, cut a piece to suitable length, and adhere this along side the customary gage or scale on a woodworking machine. This transparency and its overlay indicate how this metric tape can be used. It may wear off in time, but it is easy to replace and not very expensive.
2. OVERLAY FOR TRANSPARENCY NUMBER 1. no comment
3. METRIC MEASURING TOOLS - WOODWORK. The tools shown are those which will have to be replaced by their metric counterparts. It is unnecessary to dispose of these as they will have to be retained for customary measurement for some time to come. However, as these customary tools may need replacement, it would be wise to consider purchasing measuring tools with dual capacity; that is, those which have both the customary and metric units shown side by side. It is also recommended that some tools be purchased with a metric capacity only. There is a replacement metric blade available for the combination square.
4. TOOLS WHICH WILL NOT NEED REPLACEMENT. This chart shows the probable changes which may occur in the future relative to replacement tool sizes. The point of this slide is to show that sizes will change slightly. For example, in the hand plane,

the two inches is not converted to millimetres in which case the width would be 50.8 mm . Instead, manufacturers will probably produce a 50 mm width tool which will be slightly less than two inches wide. The same logic obtains in all of the tool dimensions shown here.

5. BORING TOOLS WHICH WILL NOT NEED REPLACEMENT. The purpose of this chart is to reassure the reader that he need not dispose of such boring tools. These will be quite usable until they wear out because their sizes convert to approximate metric equivalents, quite satisfactory in woodwork. For example, 1" equals 25.4 mm . In woodworking you can certainly use a 1" drill for a 25 mm hole. Four-tenths of a millimetre is not very much. And, of course, the expansive bit is adjustable to any metric size.
6. BORING CHART FOR WOOD SCREWS. Customary wood screws will be used for many, many years. The purpose of this chart is to show what metric drill sizes you might use for producing customary screw shank and pilot holes. The assumption here, of course, is that a set of metric drills will be one of the first tool sets which will be purchased in the woodworking lab. These will be necessary as metric sizes of hardware become available and in wide use. In this event, the teacher may find himself with a fairly complete set of metric drills but a good supply of customary wood screws. This chart will help

him to select appropriate metric drills to match the appropriate customary wood screw.

7. BRITISH WOOD STANDARDS. This chart is self-explanatory; it shows the lumber lengths, widths, and thicknesses which have been adopted in the United Kingdom. Because Britain has so recently converted to the metric system, having left the customary system which we still use, our lumber standards may approximate these.
8. PROBABLE BASIC METRIC SIZES OF SOFTWOOD LUMBER SURFACED FOUR SIDES - U.S.A. Here are shown some close approximations to probable American lumber sizes. This chart is designed to show how we might proceed with our lumber conversions in this country; that is, by converting to the nearest millimetre equivalent. For example, in the .75" or 3/4" standard, we might adopt a 19 mm size. It would be hoped, however, that we would have the good sense to round these off to the nearest millimetre in order to make them more easy with which to work. For example, a piece of half inch lumber might become 15 mm instead of 13 and a piece of 3/4" lumber might become 20 instead of 19, slightly larger in each case. Note that the same thing holds true with the metric length equivalent. We may have to retain direct metric equivalents for customary sizes for repair and modeling reasons. For example, we may have to continue to

make sheets of plywood 1.22 m by 2.44 m which is, of course, the metric equivalent for the 4' x 8' sheets of plywood. The reason for this continuance would be to accommodate stud placement in a wall section. When it comes to determining the lengths for lumber, we will probably select a 1.80 m length to approximate 6'; a 2.40 m length to approximate 8'; 3.00 m for 10'; 3.60 m for 12'; 4.2 m for 14'; 4.8 m for 16'; 5.4 m for 18'; and 6.1 m for 20'. Because there is no movement in the United States to determine metric lumber sizes, this chart should be considered for study and discussion purposes only.

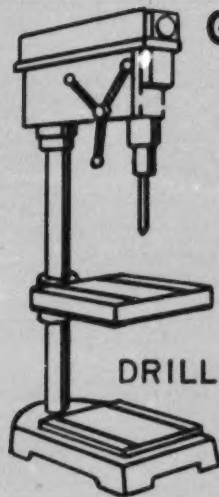
9. METRIC DRAWING--WOODWORKING (VENEERED BOX). This is a typical woodworking drawing with the millimetre as the basic unit. The conversion chart is placed on the drawing for the convenience of the reader to acquaint him with the metric and customary size equivalents.
10. PATIO TABLE. This is an example of a small piece of furniture which may be constructed in the shop using metric measuring tools. Such a metric project would be desirable for advanced woodworking students.
11. SMALL CAR GARAGE. Shown here is a floor plan of a garage using metric units and showing the placement of metric size doors and windows. The reader might well ask why one would possibly want to use such an unwieldy dimension as 6 000 mm rather than 6 m . The logic here is simple; it is to make certain that the same

unit is used throughout the drawing, to avoid confusion.

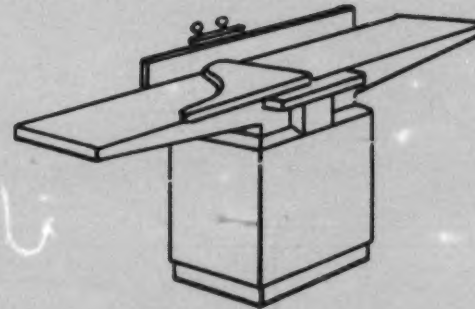
For example, one wouldn't show over-all lengths in metres, smaller sectional lengths in centimetres, and door and window sizes in millimetres. This would create a lot of confusion and create many possible sources of error.



MACHINE WOODWORK GAGE AND SCALE CONVERSION

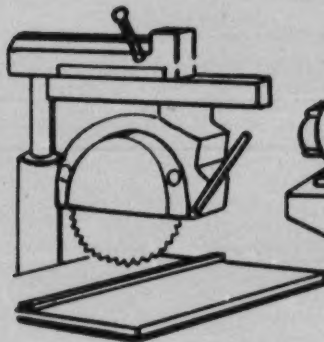


DRILL PRESS

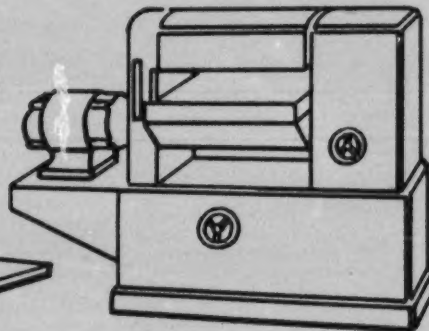


JOINTER

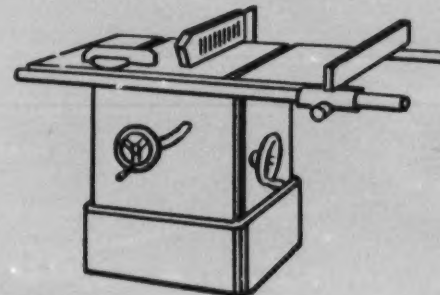
RADIAL-ARM SAW

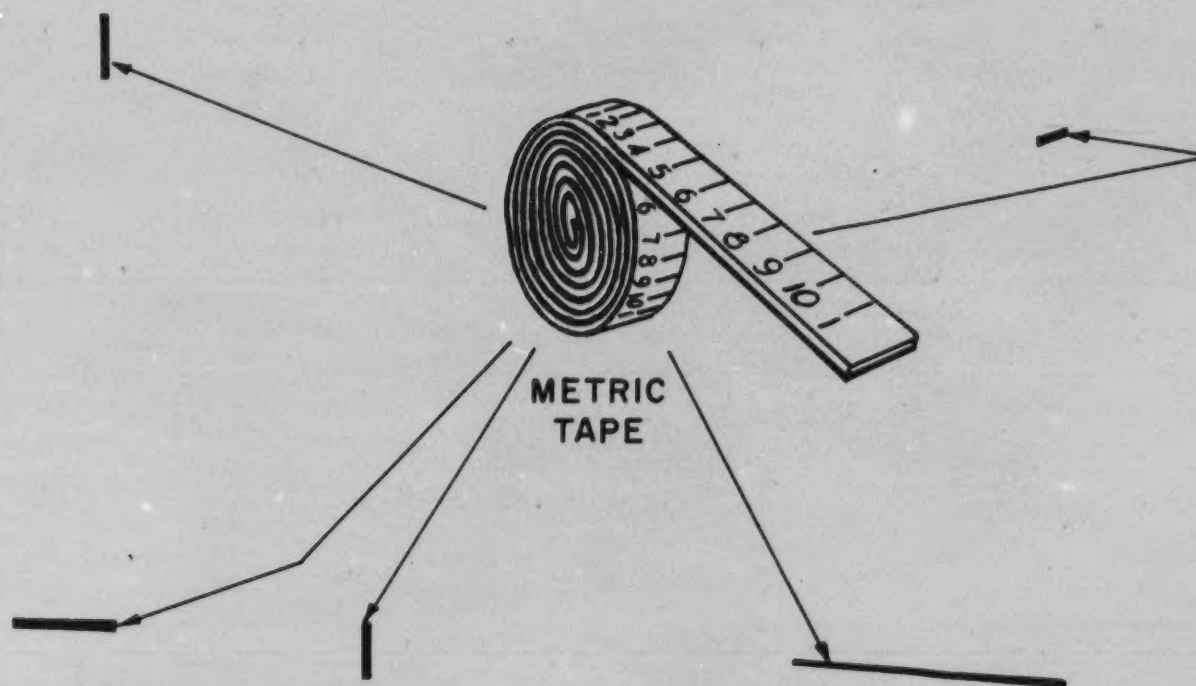


PLANER



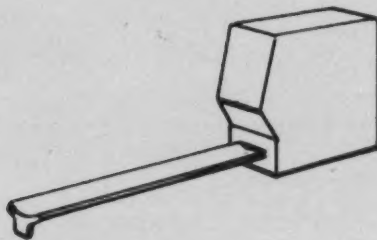
CIRCULAR SAW



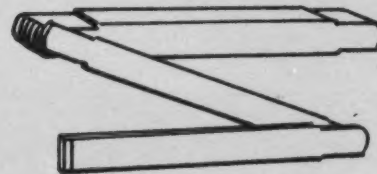




METRIC MEASURING TOOLS – WOODWORK



TAPE



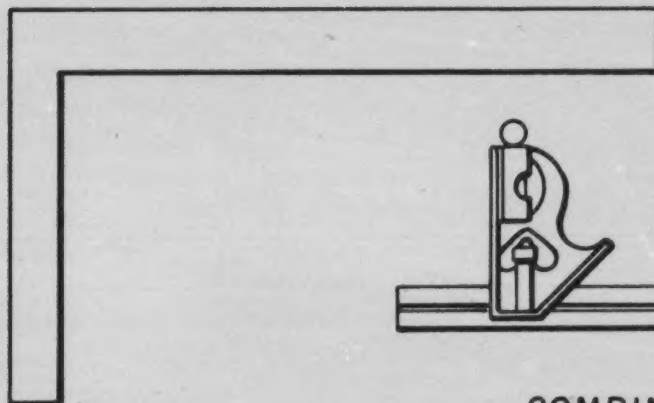
FOLDING RULE



BENCH RULE



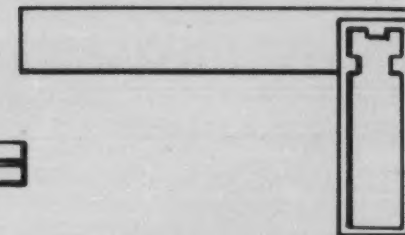
MARKING GAUGE



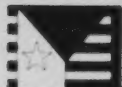
STEEL SQUARE



COMBINATION
SQUARE

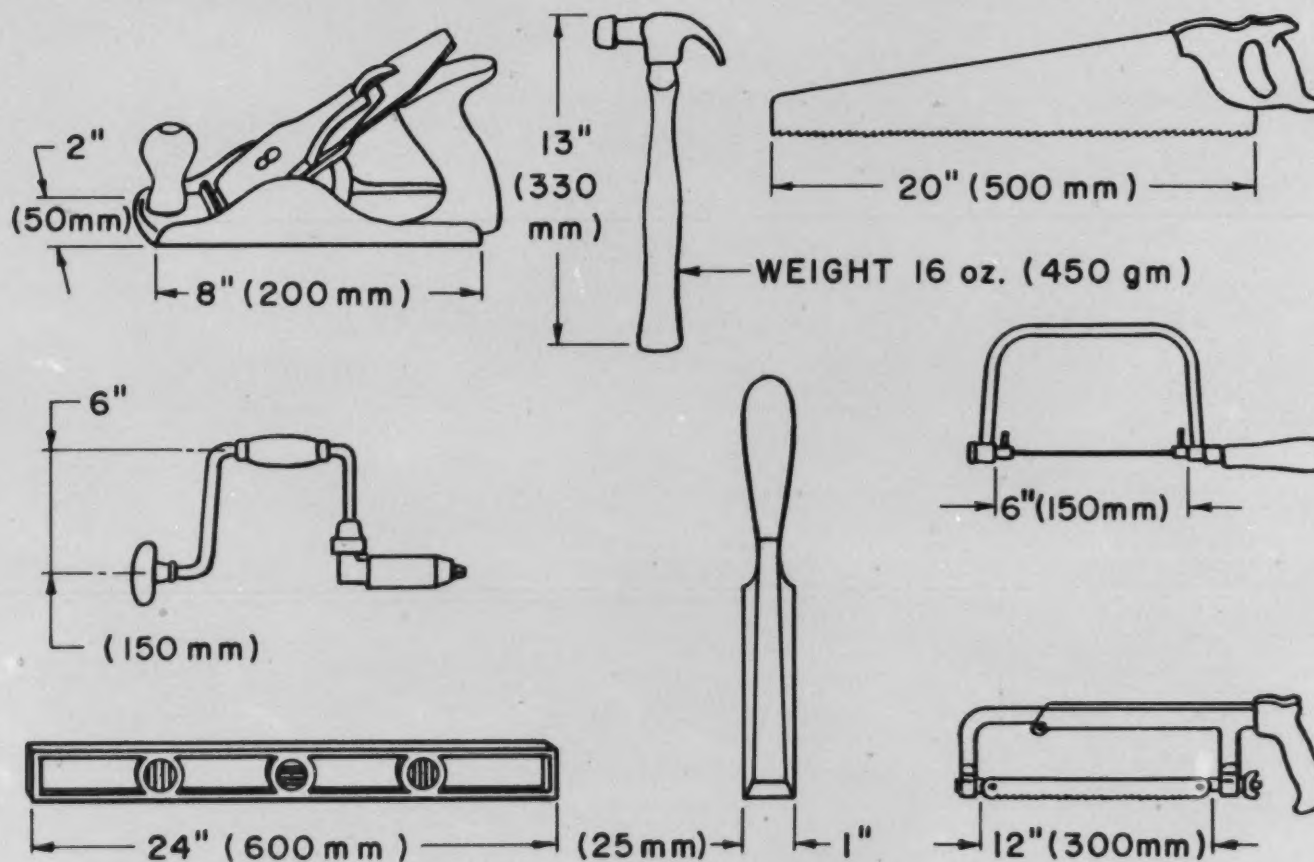


TRY SQUARE



TOOLS WHICH WILL NOT NEED REPLACEMENT

METRIC EQUIVALENTS SHOWN ARE THE EXPECTED REPLACEMENT SIZES TO BE AVAILABLE IN THE FUTURE.





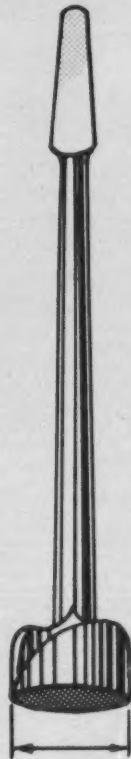
BORING TOOLS WHICH WILL NOT NEED REPLACEMENT

CONVERT THESE BY ASSIGNING APPROXIMATE METRIC EQUIVALENTS
TO STANDARD BIT SIZES.



3/4"

19 mm



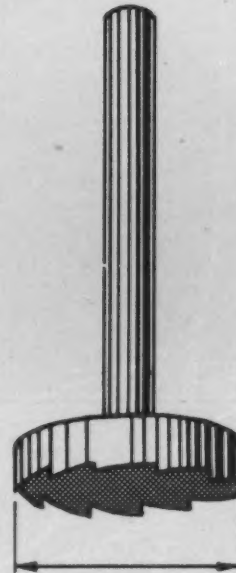
1"

25 mm



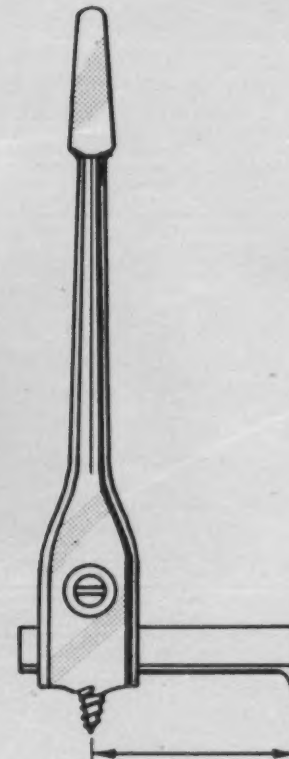
5/8"

16 mm



2"

50 mm



ADJUSTABLE TO ANY
METRIC SIZE.



BORING CHART FOR WOOD SCREWS

Customary and Metric Sizes

No. of Screw	Max. Head Dia. Inch	SHANK DIAMETER		ROOT DIAMETER		Thread per Inch	No. of Screw
		Basic Dec. Size Inch	Nearest Drill Equivalent Inch mm	Average Dec. Size Inch	Nearest Drill Equivalent Inch mm		
0	.119	.060	1/16 1.5	.040	3/64 1.0	32	0
1	.146	.073	5/64 2.0	.046	3/64 1.0	28	1
2	.172	.086	3/32 2.5	.054	1/16 1.5	26	2
3	.199	.099	7/64 3.0	.065	1/16 1.5	24	3
4	.225	.112	7/64 3.0	.075	5/64 2.0	22	4
5	.252	.125	1/8 3.5	.085	5/64 2.0	20	5
6	.279	.138	9/64 3.5	.094	3/32 2.5	18	6
7	.305	.151	5/32 4.0	.102	7/64 2.5	16	7
8	.332	.164	5/32 4.0	.112	7/64 2.5	15	8
9	.358	.177	11/64 4.5	.122	1/8 3.0	14	9
10	.385	.190	3/16 5.0	.130	1/8 3.0	13	10
11	.411	.203	13/64 5.5	.139	9/64 3.5	12	11
12	.438	.216	7/32 5.5	.148	9/64 3.5	11	12
14	.491	.242	1/4 6.5	.165	5/32 4.0	10	14
16	.544	.268	17/64 7.0	.184	3/16 4.5	9	16
18	.597	.294	19/64 7.5	.204	13/64 5.0	8	18
20	.650	.320	5/16 8.0	.223	7/32 5.5	8	20
24	.756	.372	3/8 9.5	.260	1/4 6.0	7	24



BRITISH WOOD STANDARDS

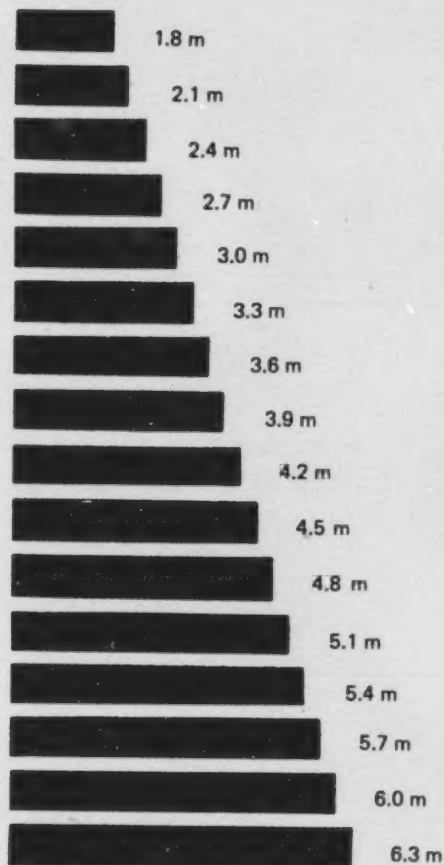
METRIC MEASURES FOR WOOD AND BOARD

You have been used to buying timber in imperial measure; lengths by the foot and sections in inches. Now it comes from the mills in standard metric lengths and sections and will be sold to you in metric measure. Where you used to think of lengths in feet think now in METRES (m) and where you thought of inches for sections think now of MILLIMETRES (mm).

LENGTHS

The new range of lengths supplied from the mills begin at 1.8 metres and increase in steps of 300 millimetres (300 mm) to 6.3 metres. Shorter and longer lengths can be obtained. 300 mm is close to, but shorter than, a foot.

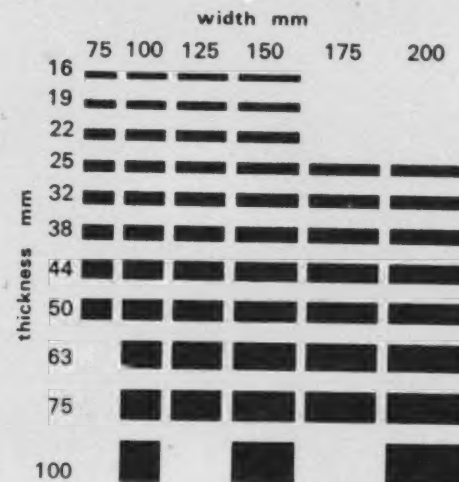
The diagram opposite shows you the new metric lengths. Note that 300 mm is the same as 0.3 metres or 30 centimetres.



Not actual size

SECTIONS

Most of the metric sizes of sections and mouldings are very close to the customary inch sizes. They are very slightly smaller.



Not actual size

BOARD AND SHEET MATERIALS

These materials are also now sold in metric lengths, widths and thicknesses. For practical purposes, the dimensions are no different from those you are used to.



Probable Basic Metric Sizes of Softwood

Lumber Surfaced Four Sides

U.S.A.

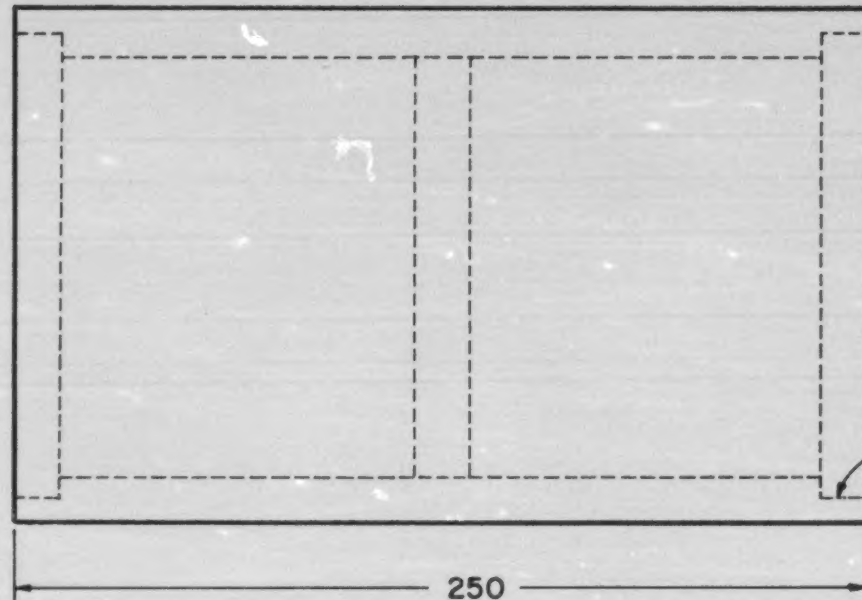
Thickness		Width in mm						
Approx.								
Inches	mm	50	75	100	150	200	250	300
.5	13	x	x	x	x	x	x	x
.75	19	x	x	x	x	x	x	x
1	25	x	x	x	x	x	x	x
1.5	38	x		x	x	x	x	x
2	50	x		x	x	x	x	x
4	100	x		x	x	x	x	x
6	150	x		x	x	x	x	x
8	200	x		x	x	x	x	x
10	250	x		x	x	x	x	x
12	300	x		x	x	x	x	x
Length:		1.83 m (6')	2.44 m (8')	3.05 m (10')	3.66 m (12')			
		4.27 m (14')	4.88 m (16')	5.49 m (18')	6.10 m (20')			

Probable 4' x 8' Panel Size: 1220 mm x 2440 mm, or
1.22 m x 2.44 m

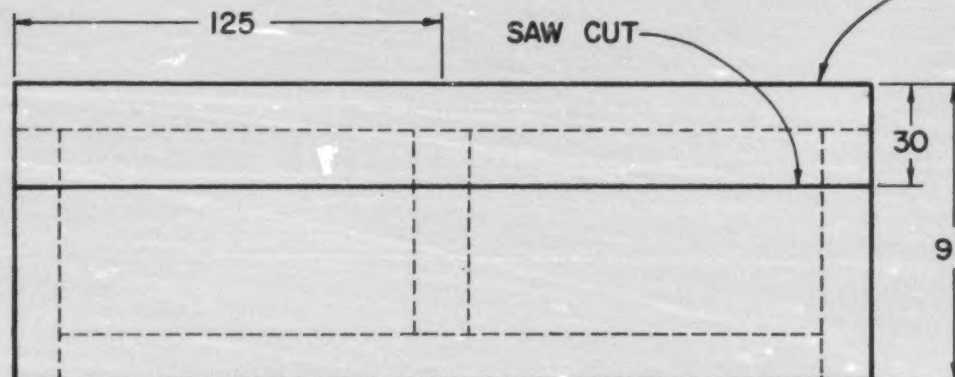


METRIC DRAWING—WOODWORKING (VENEERED BOX)

CONVERSION CHART		
mm	decimal inch	inch to nearest 16th
30	1.181	1 3/16
75	2.953	2 15/16
91	3.583	3 9/16
125	4.921	4 15/16
150	5.905	5 7/8
250	9.842	9 13/16



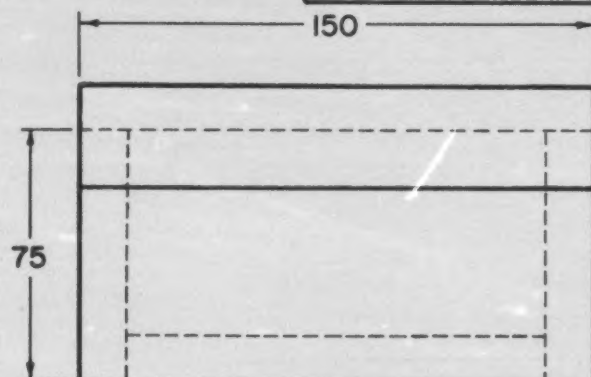
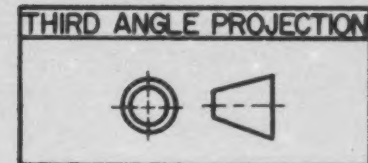
RABBET JOINT
4 PLACES



1 mm VENEER

NOTE:

16 mm BASSWOOD USED
HARDWARE TO SUIT



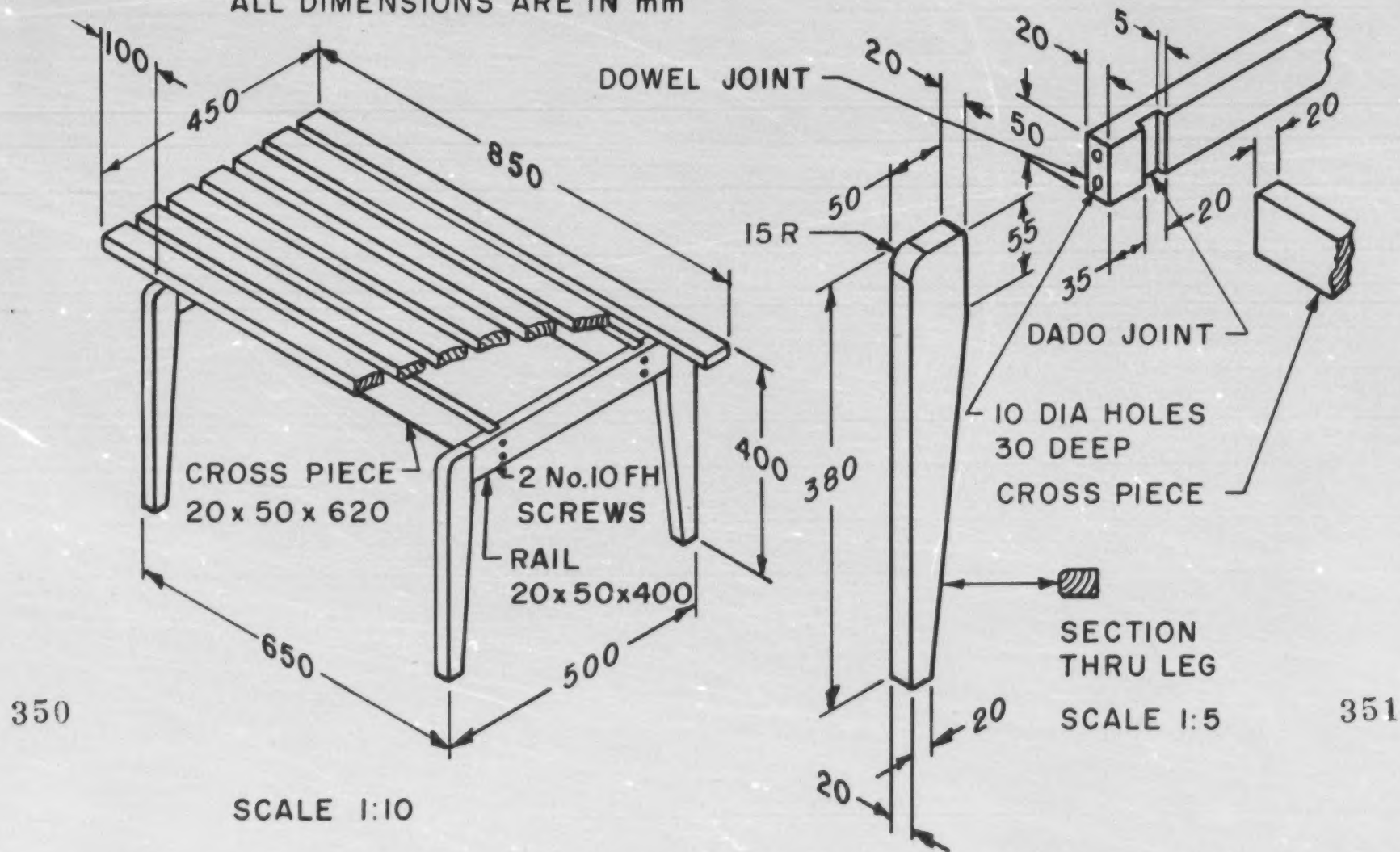


CENTER FOR METRIC EDUCATION • WESTERN MICHIGAN UNIVERSITY

PATIO TABLE

MATERIAL - PINE

ALL DIMENSIONS ARE IN mm



COURSE OUTLINE FOR METRIC MEASUREMENT AND ISO STANDARDS

The attached course outline can be used for a teaching unit of any length. A bibliography of resource material is attached.

Section One - Early History of Measurement

1. Early Civilization and Metrology (the science of measurement)

Earliest linear measurements based on body

Ancient units of mass and volume based on coins, stones, etc.

2. Measurement in the Middle Ages

Units of length continued to be based on body measurement

Units of mass were associated with monetary units and precious metals

England developed the Imperial System based on the "iron ulna"

3. Evolution of the Metric System

Early French history of measurement

Development of the linear measurement based on the metre--equivalent to one, 10-millionths part of the meridian quadrant

Early C.G.S. metric system

M.K.S. metric system

SI metric system

Importance of changing to the metric system

Section Two - SI Metric System Basic (use Going Metric for Career Teachers)

1. Three systems of measurement

2. Seven basic units

metre = length
kilogram = mass
second = time
kelvin = temperature
ampere = electrical current
candela = luminous intensity
mole = amount of substance

3. Two supplementary units - radian and steradian

4. Derived units - newton, joule, watt, pascal

5. Prefixes, multiples, and submultiples

6. Rules for using SI units

Section Three - Applied Metric System

1. Length--the metre (m)

Basic definition

Multiples and submultiples in common use

Applied problems

Conversion factors

2. Area--square metre (m²)

Basic definition

Length x length

Square metre

Hectare

Square kilometre

Applied problems

Conversion factors

3. Volume--cubic metre (m^3)

Basic definition

Cubic metre

Cubic decimetre--litre

Cubic centimetre

Applied Problems

Conversion factors

4. Liquid capacity--litre (l)

Basic definition

Millilitre and kilolitre

Applied problems

Conversion factors

5. Mass--kilogram (kg)

Difference between mass and weight

Weight in kilograms

Newton as a unit of force

Applied problems

Conversion factors

6. Temperature--degrees Celsius ($^{\circ}\text{C}$)

Three basic temperature scales

kelvin

Fahrenheit

degrees Celsius

Use of degrees Celsius scale

Conversion from Fahrenheit to degrees Celsius

Section Four - National and International Standards

1. Groups involved
American National Standards Institute (ANSI)
International Organization for Standardization (ISO)
2. Difference between metric measurement and ISO standards
3. Need for metric standards
4. ISO paper sizes
5. ISO thread sizes

Section Five - Metric Drafting

When applying the metric system to drawing, the most important tool is the scale. Since linear measure is the most important factor in metric drafting, knowledge and application of linear measure is primary. Metric sized templates will be useful and necessary. A thorough knowledge of metric measure and a good understanding of the following unit will give enough background to begin metric drafting.

1. Scales

Metric linear measure is the most important aspect of metrics in regard to drafting. Hence, a knowledge of metric scales is essential.

2. Conversion charts

Metric conversion charts are necessary for conversion from the inch system.

3. Rounding and linear sizes

Specific rounding rules and linear sizes are necessary for uniform metric design.

4. ISO paper sizes

Note the changes made in paper sizes.

5. Orthographic projection

Note the changes from third to first-angle projection.

6. Abbreviations and symbols

7. Dimensioning

At present, we are concerned with a comparison of customary and metric dimensioning. There are several transitional dual methods used. Eventually, the draftsman will be concerned with only metric dimensions.

8. Metric drawing

When designing in metric measure, it is essential to use specified metric lengths and sizes to insure conformity to metric standards.

9. Threads

10. Measurement

11. Templates

Certain types of metric templates will facilitate faster drawing in metric sizes. Such templates as circle, ellipse, isometric, hexagon nuts and bolts, screw thread, and radius guide would be very helpful.

12. Textbooks

Presently, a good metric drafting text that would meet the need of basic introduction to metrics in drafting isn't available. However, a good source of information for the teacher would be:

U.S. Metric Study Interim Report
Engineering Standards
U.S. Department of Commerce
National Bureau of Standards, NBS SP 345-11

and is available from:

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

Section Six - Metalworking

Drafting and metalworking will be the two areas most immediately affected by conversion to metric measurement and by the use of ISO standards. These two areas are closely related, since precision measurement is an essential part of both instructional areas. The following is an outline for a unit to be covered in any metalworking or machine shop course.

1. Measuring tools

The common metric measuring tools include metric rules or scales, micrometers, verniers, feeler gages, and other measuring instruments such as dial indicator gages. All of these items must be replaced in order to do metric metalworking.

2. Threads

The two basic types of threads are the ISO metric series and the ISO inch (commonly known as the unified national series). While the shape is identical, they are not compatible.

3. Thread series

4. Cutting internal threads with taps

5. Cutting external threads with dies

6. Cutting external metric threads on a lathe

7. The difference between IFI metric series and the ISO metric and inch series

8. Wrenches for use with metric fasteners

9. Four types of dimensioning practices used in metal manufacturing

Dual dimensioning

Metric dimensioning with customary read-out chart

Master drawing unidimensional with metric on one copy and customary on the other

Use of identification letters

10. Making a project with metric measurements and ISO threads

Machinists toolmaker's clamps

Hammerhead

Casting

11. Converting machine shop equipment

Lathe conversion

Metric threading attachment

Dual reading dial--two basic types

All large equipment can be converted with digital read-out equipment

Heat treating--the use of pyrometers and other equipment with degree Celsius temperature scales

12. Textbooks

Many of the leading publishers are including metric measurement in current editions.

Section Seven - Metric Woodworking

Measuring tools are an important factor in getting started in metric woodworking. Efforts must be made to engage students in using metric tools and "thinking metric" by having them make a simple project according to metric sizes or gain metric measuring practice through exercises. Some measuring tools will, therefore, need replacement; but customary measuring tools will be used for some time. Woodworking machines will not require replacement because they can be adjusted to cut materials to any desired size including metric.

By knowing and understanding some simple metric practices, the woodworking teacher can acquire facility in helping students to work out metric problems.

1. Woodworking machines

Woodworking machines need not be replaced. Instead, one can make a simple conversion by applying metric tape along side existing customary scales on machines.

2. Woodworking tools

The measuring tools used in woodworking will have to be replaced gradually as customary tools wear out. It is a good idea to get tools that have a dual capacity. Most of the other tools, however, will not have to be replaced. In the future, they will be specified according to metric instead of customary sizes.

3. Boring holes for wood screws

Customary fasteners and hardware items will be used for many years in woodworking programs. Such items as wood screws, nails, hinges, drawer pulls, etc., will not be affected for some time by metric conversion. However, as customary drills are replaced by metric drills, the teacher will find it necessary to use these for boring pilot and shank holes for wood screws. The included chart will aid in this selection.

4. Lumber standards

The woodworking organizations in the United States are not presently involved in writing new metric standards for wood products. This is a task which will face them in the future. In order to become familiar with these sizes, we can look to the "British Wood Standards" which give some indication of what ours might be. Our lumber sizes may continue to be influenced by the placement of studs in a wooden wall. For example, 16" or 24" centers determine that we will require something similar to a 4' x 8' sheet of plywood. We will still find it necessary, however, to retain customary lumber sizes for repairs and remodeling.

5. Wood projects

Simple wood projects designed according to metric dimensions will help the students acquire a feeling for metric measurements. Architectural drawings will be somewhat influenced by lumber standards.

6. Textbooks

At present, a good woodworking textbook that would help the teacher is not available. It is anticipated that woodworking textbooks with a unit on metric measurement will be available in a few years. In the meantime, the teacher will have to rely upon government publications and documents as they become available.

Section Eight - Graphic Arts

The major items affecting the graphic arts teacher will be ISO paper and envelope sizes. Also, eventually, all cold-type layouts will be in metric sizes.

1. ISO paper sizes
 - How developed
 - Comparison to present sizes
 - Paper weights
 - Envelope sizes
2. Printers units
 - Points
 - Fractions
 - Decimal
 - Metric
3. Comparison of measuring systems

Section Nine - Selected Metric Bibliography

REFERENCES

1. Beloit Tool Company. U.S.A. Goes Metric. South Beloit, IL: Swani Publishing Company, 1971.
2. Cameron, Clive A. Going Metric with the U.S. Printing Industry. Rochester, NY: Graphic Arts Research Center, Rochester Institute of Technology, 1972.
3. Donovan, Frank. Prepare Now for a Metric Future. New York: Weybright and Talley, 1970.
4. International Standards Organization. Bulletin R-1000. New York: The American National Standards Institute.
5. The Modernized Metric System. Chart. NBS Publication 304. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1972.
6. Oberg, Eric, and Franklin D. Jones. Machinery's Handbook. New York: The Industrial Press, 1971.
7. Ploutz, Paul F. The Metric System: A Programmed Approach. Columbus, OH: Charles E. Merrill Publishing Company, 1972.
8. U.S. Metric Study Committee. A Metric America. NBS Publication 345. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, 1971 (13 reports).

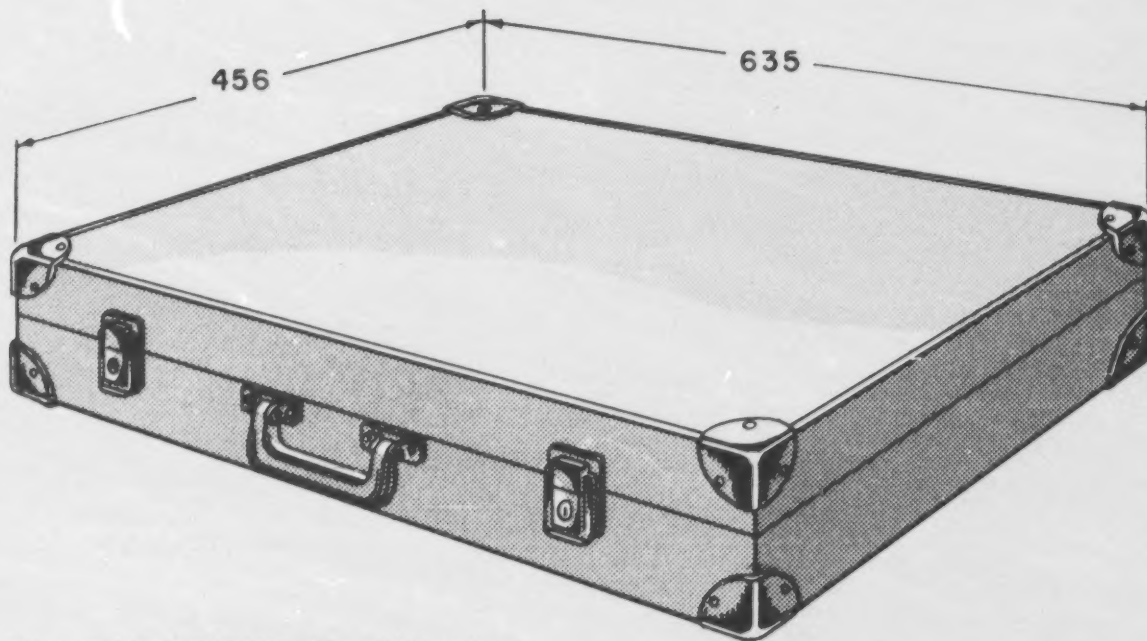
FILM MATERIALS

1. Metric or English? That is the Question. Chicago: Society for Visual Education, Inc. Four sound filmstrips.
2. The Metric System. Chicago: Cornet Films. Film, 16 mm, color, 11 min.
3. The Metric System. San Jose, CA: The Lansford Publishing Company. Ten transparencies.
4. The Metric System. New York: Pathescope Educational Films, Inc. Six sound filmstrips.
5. Metric Weights and Measures. Wichita, KA: Library Filmstrip Center. Sound filmstrip.
6. Think Metric. Chicago: Denoyer-Geppert Company. Eighty slides.
7. Understanding the Metric System. University Park, PA: The Pennsylvania State University. Film, 16 mm, color, 10 min.

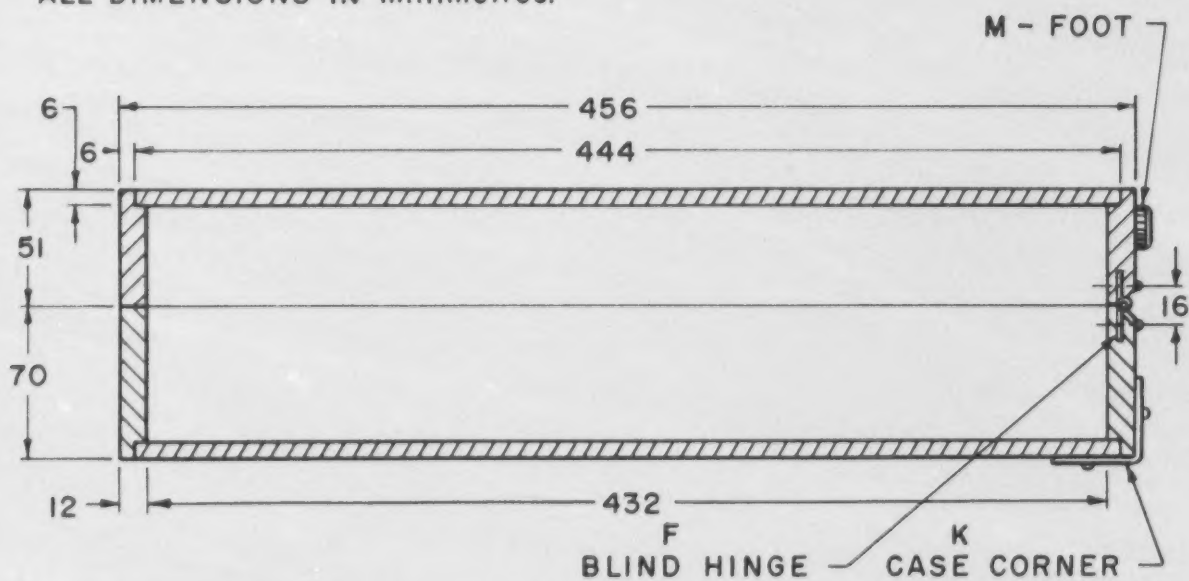


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METRIC MATERIAL CARRYING CASE

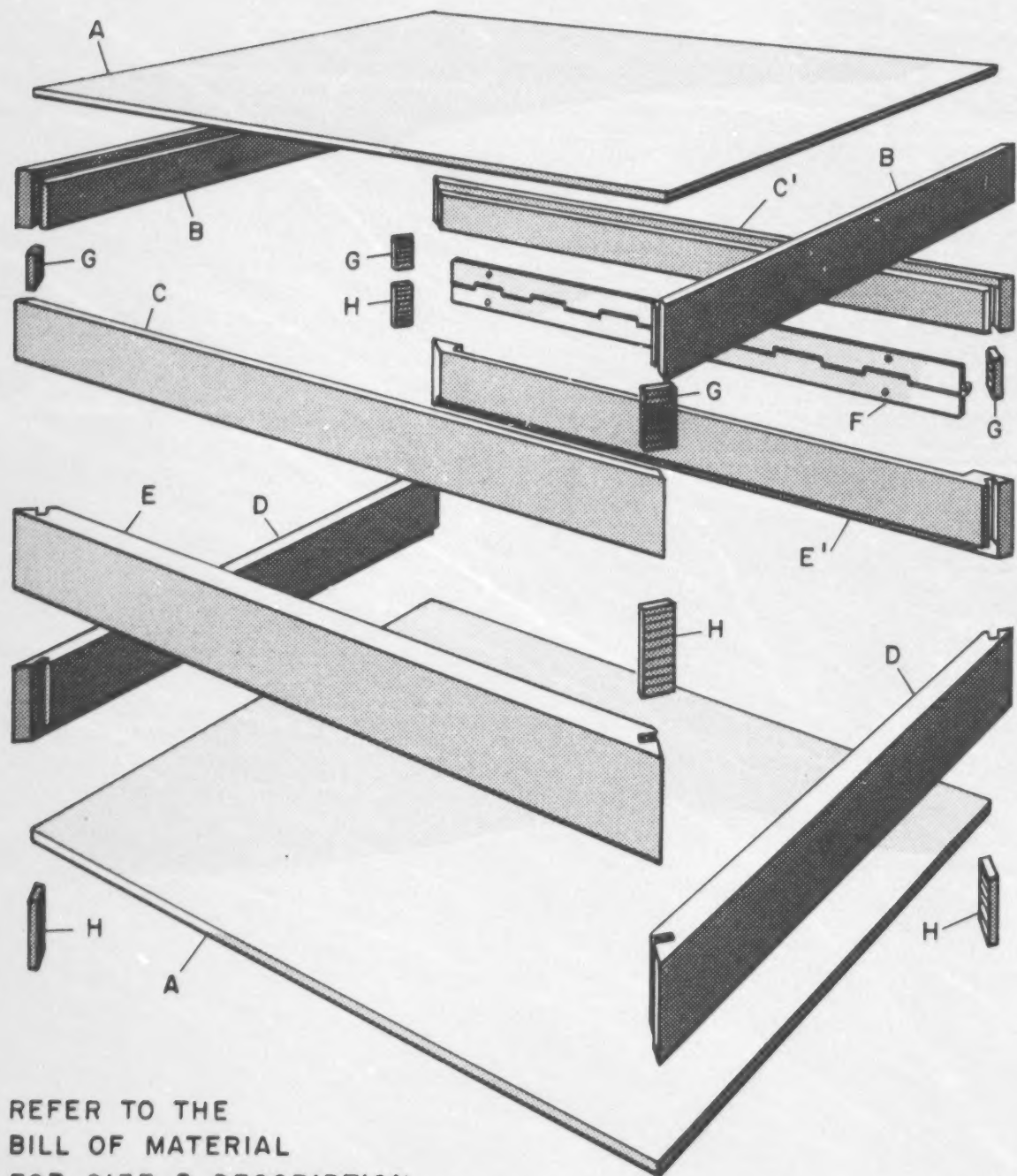


ALL DIMENSIONS IN millimetres.

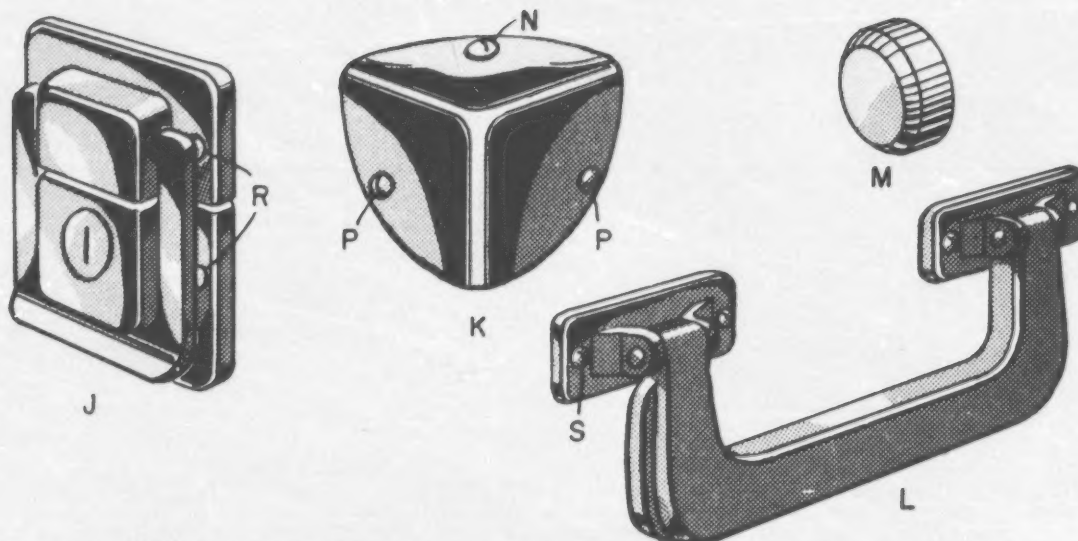


SECTION THROUGH THE CENTER OF THE CASE FROM TOP TO BOTTOM

CASE COMPONENTS

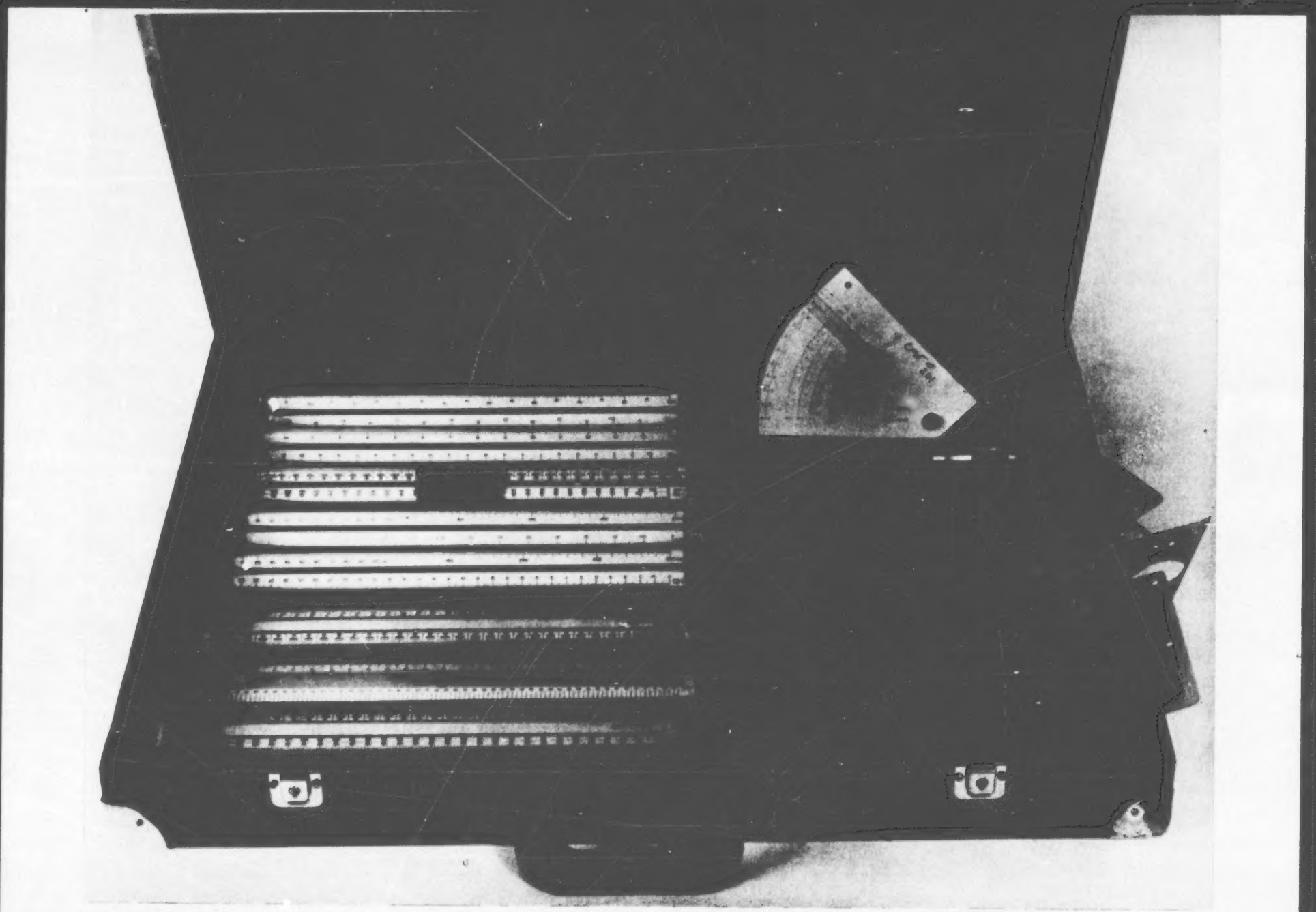


REFER TO THE
BILL OF MATERIAL
FOR SIZE & DESCRIPTION.



BILL OF MATERIAL

CODE NO.	SIZE IN mm	DESCRIPTION	NOTES
A	2	6 x 444 x 622	PANEL
B	2	12 x 51 x 456	END PIECE TOP
C	2	12 x 51 x 635	SIDE PIECE TOP
D	2	12 x 70 x 456	END PIECE BOX
E	2	12 x 70 x 635	SIDE PIECE BOX
F	1	3 x 25 x 345	BLIND HINGE CONTINUOUS
G	4	3 x 44 x 8	SPLINE TOP
H	4	3 x 62 x 8	SPLINE BOX
J	2	10 x 30 x 45	SURFACE LOCK BRASS
K	8	2 x 35	CASE CORNER BRASS
L	1	125 GRIP	HANDLE BROWN GRIP
		FITTINGS	BRASS PLATE
M	4	6 x 19 DIA.	FOOT BROWN PLASTIC
N	8	2 x 6 LONG	WOOD SCREW BRASS - CORNER
P	16	2 x 10 LONG	WOOD SCREW BRASS - CORNER
Q	6	2 x 10 LONG	WOOD SCREW BRASS - HINGE
R	8	3 x 15 LONG	WOOD SCREW BRASS - LOCK
S	4	4 x 15 LONG	WOOD SCREW BRASS - HANDLE



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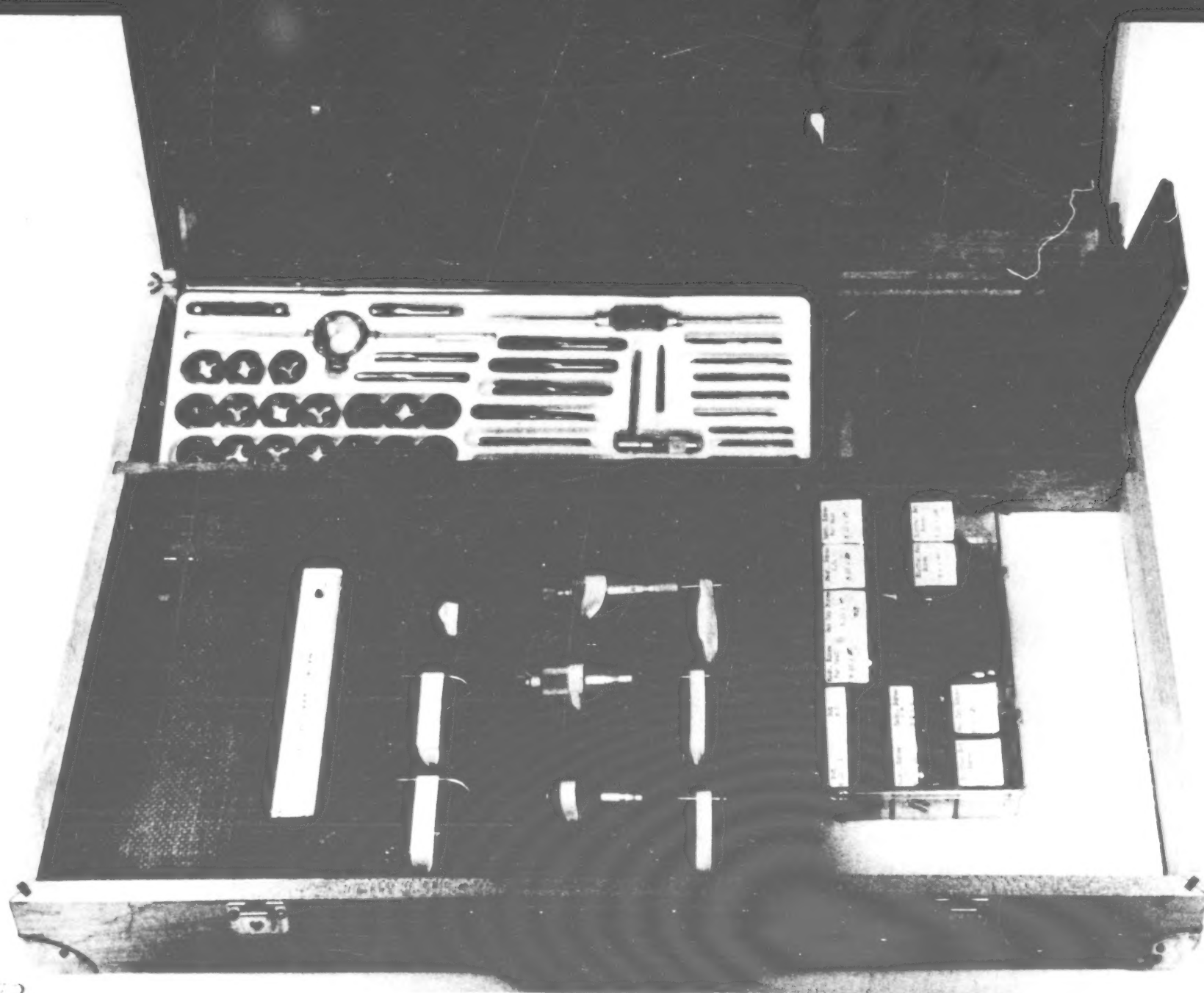
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METRIC TOOL LIST FOR DRAFTING

Tool Name	Brand	Tool Size/ Capacity	Purchase Price (unit)	Purchased From
(1) Adjustable Set Square	British Thorton	250 mm	\$ 6.95	Lythorn Corporation 162 Newbury Street Boston, MA 02116
(2) Double Bevelled Perspex Ruler	Blundell Harling	300 mm	\$ 2.20	Central Instrument Co. 900 Riverside Drive New York, NY 10032
(3) Oval Scales	Blundell Harling	300 mm	\$ 4.95	same as above
(4) Radius Curve Templet	Hellerman	2 mm to 25 mm	\$.34	Esmond Hellerman, Ltd. Hellerman House Sunbury Trading Estate Windmill Road Sunbury-on-Thames Middlesex, TW16 7EW England
(5) Triangle Drafting Scales	Hellerman	various sizes	\$ 2.00	same as above
(6) Templates	RapiDesign	various types	from - \$ 1.00-\$3.50	RapiDesign, Inc. P.O. Box 6039 Burbank, CA 91505
(7) Digit Micrometer	Mitutoyo	0-25 mm	\$34.25	Mitutoyo Mfg. Co., Ltd. 11 East 26th Street New York, NY 10010
(8) Vernier Caliper	General	12.7 cm 5 inch	\$ 3.50	General Hardware Mfg. Co., Inc. New York, NY 10013
(9) Pull Tape Measure	Stanley	3 m	\$ 3.35	Stanley Tools New Britain, CT 06050

Other Metric Tool Suppliers:

Roe & Sons, Inc.
Patchogue, NY 11772
(No. 9)



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METRIC TOOL LIST FOR GENERAL METALS

Tool Name	Brand	Tool Size/ Capacity	Purchase Price (unit)	Purchased From
(1) Drill Index	Mitutoyo	1 mm to 5.9 mm	\$16.90	Mitutoyo Mfg. Co. Ltd. 11 East 26th Street New York, NY 10010
(2) Metric Micrometer No. 1142767	Mitutoyo	0-25 mm	\$20.00	same as above
(3) Combimike No. 159-211	Mitutoyo	0-1" 0-25 mm	\$32.25	same as above
(4) Metric Micrometer Catalog No. MP1 71-1	Regal Beloit	0-25 mm	\$17.50	Regal Beloit Tool Corp. P.O. Box 128 South Beloit, IL 61080
(5) 3-Plastic Rulers	Metric Assoc., Inc.	20 cm	\$ 1.00	Metric Association, Inc. 2004 Ash Street Waukegan, IL 60085
(6) Screw Pitch Gages	Mitutoyo	M2-M60 mm	\$ 1.23	Mitutoyo Mfg. Co., Ltd.
(7) 6-Stainless Steel Rules	Mitutoyo	300 mm 12 inch	\$ 1.23 ea.	Mitutoyo Mfg. Co., Ltd.
(8) 2-Steel Tape Measures	Mitutoyo	2 m	\$ 1.23 ea.	Mitutoyo Mfg. Co., Ltd.
(9) 40-Piece Tap & Die Set #71437	Premier	Metric	\$16.95	Edmund Scientific Co. 801 Edscorp Bldg. Barrington, NJ 08007
(10) Assorted Bolts, Nuts, and Screws	Zelenda	all sizes		Zelenda Machine & Tool Corp. Metric Division 66-02 Austin Street Forest Hills, NY 11374

Other Metric Tool Suppliers:

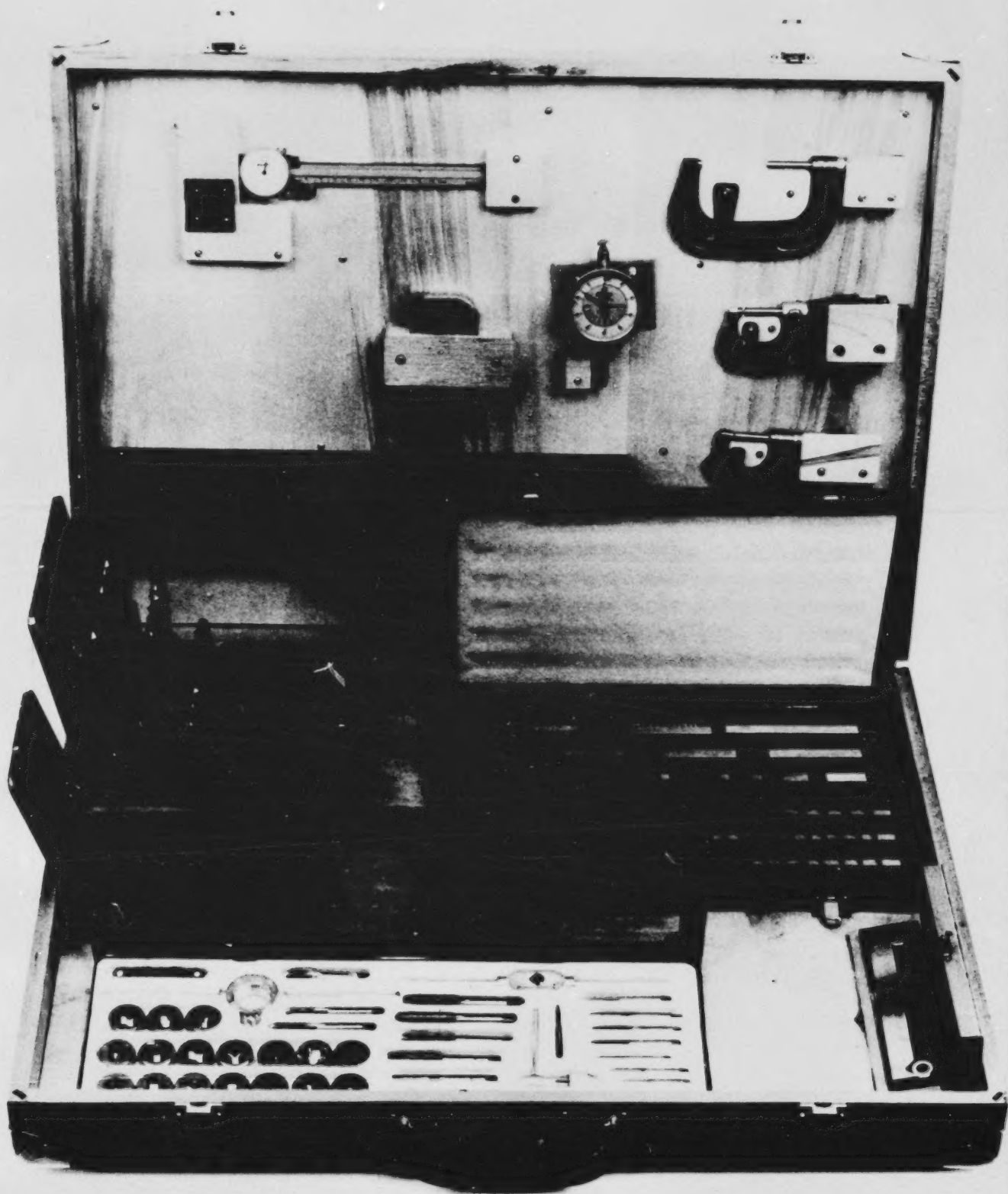
Brown & Sharpe Mfg. Co.
Industrial Products Div.
Precision Park
North Kingstown, RI 02852
(Nos. 2,3,4,5,6,7)

Stanley Tools
New Britain, CT 06050
(No. 8)

The L.S. Starrett Co.
Athol, MA 01331
(Nos. 2,4,6,7,8)

Zelenda Machine & Tool Corp.
Metric Division
66-02 Austin Street
Forest Hill, NY 11374
(Nos. 1,2,6,9,10)

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METRIC TOOL LIST FOR MACHINE SHOP

Tool Name	Brand	Tool Size/ Capacity	Purchase Price (unit)	Purchased From
(1) Dial Indicator	Mitutoyo #2048E	10 mm	\$ 13.50	Mitutoyo Mfg. Co., Ltd. 11 East 26th Street New York, NY 10010
(2) Drill Index	Mitutoyo	1 mm to 5.9 mm	\$ 16.90	same as above
(3) Drill Index	Mitutoyo	6 mm to 12 mm	\$ 60.95	same as above
(4) Inside Micrometer	Mitutoyo #145-185	5 mm to 25 mm	\$ 26.60	same as above
(5) Direct Reading Digit Micrometer	Brown & Sharpe #599-10-100	0-25 mm	\$ 34.50	Brown & Sharpe Mfg. Co. Industrial Products Div. Precision Park North Kingstown, RI 02852
(6) Anglometric Micrometer	Regal Beloit	0-25 mm	\$ 24.50	Regal Beloit Tool Corp. P.O. Box 128 South Beloit, IL 60085
(7) Anglometric Micrometer	Regal Beloit	50 mm to 75 mm	\$ 36.50	same as above
(8) Gage Blocks 87 pcs.	Mitutoyo #516-946	Metric	\$745.00	Mitutoyo Mfg. Co., Ltd.
(9) Screw Pitch Gage	Regal Beloit	0.25 mm to 6 mm	\$ 2.50	Regal Beloit Tool Corp.
(10) Stainless Steel Comparison Rules	General #40,073	150 mm 6 inch	\$.50	Edmund Scientific Co. 801 Edscorp Bldg. Barrington, N.J. 08007
(11) Stainless Steel Rules	Mitutoyo	300 mm 12 inch	\$ 1.23	Mitutoyo Mfg. Co., Ltd.
(12) Sine Bar	Regal Beloit S-10		\$ 25.00	Regal Beloit Tool Corp.

METRIC TOOL LIST FOR MACHINE SHOP, p. 2

Tool Name	Brand	Tool Size/ Capacity	Purchase Price (unit)	Purchased From
(13) Vernier Caliper	Mitutoyo	150 mm	\$31.00	Mitutoyo Mfg. Co., Ltd.
(14) 40-Piece Tap & Die Set	Premier	Metric & Metric Fine Taps & Dies	\$16.95	Edmund Scientific Co.
(15) Assorted Bolts, Nuts, Screws	Zelenda	all sizes	varies	Zelenda Machine & Tool Corp. Metric Division 66-02 Austin Street Forest Hills, NY 11374
(16) Pull Tape Measure	Mitutoyo	Dual-Reading 2 m	\$ 1.23	Mitutoyo Mfg. Co., Ltd.

Other Metric Tool Suppliers:

A.O.R. Tool Corporation
82-21 Sutter Avenue
Ozone Park, NY 11417
(Nos. 1,6,7, 13)

Brown & Sharpe Mfg. Co.
Industrial Products Division
Precision Park
North Kingstown, RI 02852
(Nos. 1,6,7,9,10,13)

Mitutoyo Mfg. Co., Ltd.
11 East 26th Street
New York, NY 10010
(Nos. 5,6,7,9,10,11,13,14)

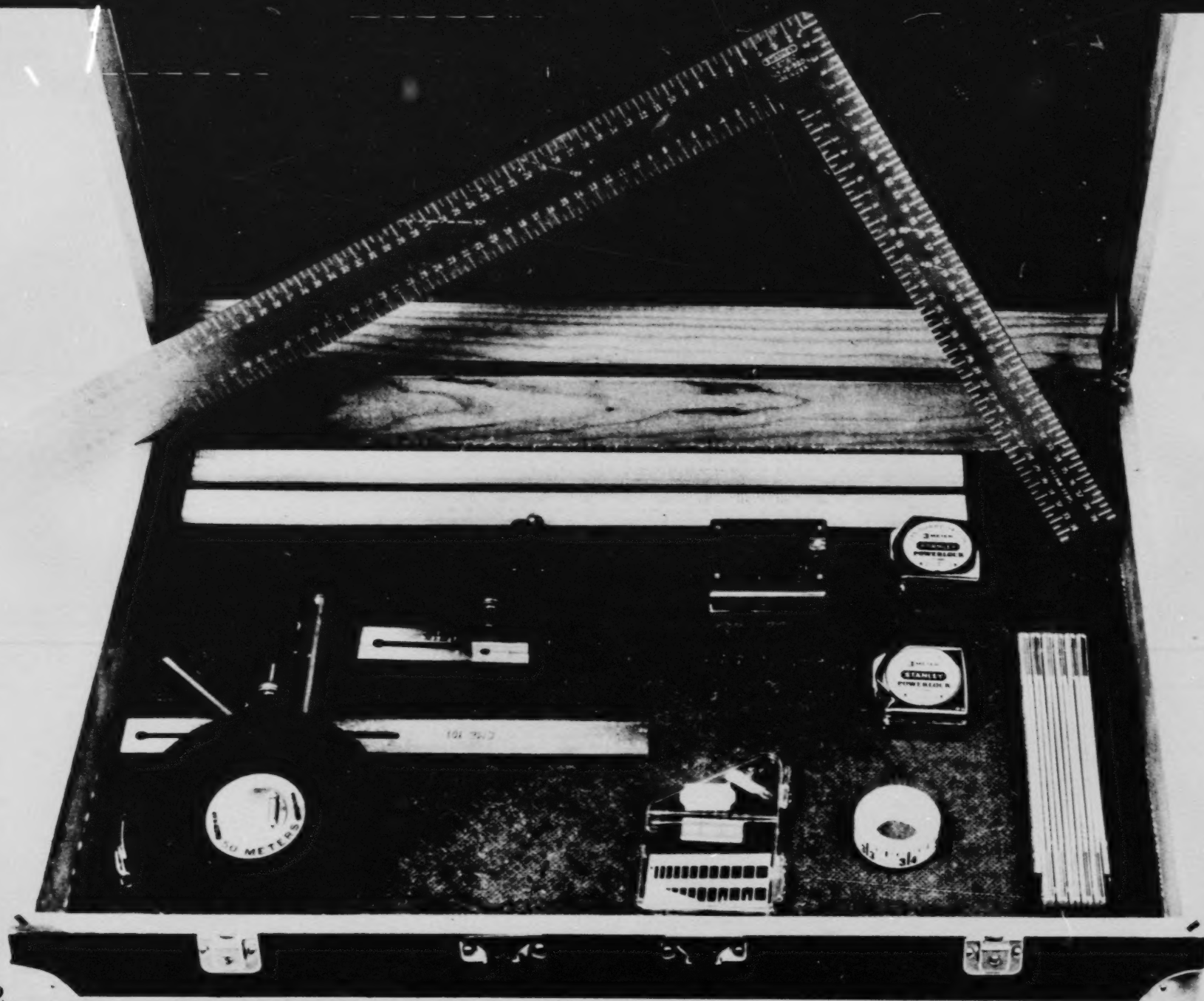
Regal Beloit Tool Corp.
P.O. Box 128
South Beloit, IL 60085
(Nos. 1,5,8,10,13)

Roe & Sons, Inc.
Patchogue, NY 11772
(No. 16)

Stanley Tools
New Britain, Connecticut 06050
(No. 16)

The L.S. Starrett Co.
Athol, MA 01331
(Nos. 1,4,6,7,8,9,10,11,13,16)

Zelenda Machine & Tool Corp.
Metric Division
66-02 Austin Street
Forest Hills, NY 11374
(Nos. 1,2,3,6,7,9,13,14)



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METRIC TOOL LIST FOR WOODWORKING

Tool Name	Brand	Tool Size/ Capacity	Purchase Price (unit)	Purchased From
(1) Combination Square	Stanley	30.5 cm/12 in.	\$ 5.49	Stanley Tools New Britain, CT 06050
(2) Drills	Western Germany	1.5 mm-6.5 mm	\$ 6.19	Edmund Scientific Co. 801 Edscorp Bldg. Barrington, NJ 08007
(3) Framing Square	Stanley	609 mm x 46 mm	\$ 8.10 (approx.)	Stanley Tools
(4) Pressure-Sensitive Tape		cm tape	\$ 1.00	Edmund Scientific Co.
(5) Power Lock Steel Tape	Stanley	3 m	\$ 3.35	Stanley Tools
(6) Steel Tape	Stanley	50 m	\$38.30	Stanley Tools
(7) Steel mm & inch Tape	Mabo nivometre	3 m	\$ 7.71	Edmund Scientific Co.
(8) Wooden Bench Rule		500 mm	\$.60	Esmond Hellerman, Ltd. Hellerman House Sunbury Trading Estate Windmill Road Sunbury-on-Thames Middlesex, TW16 7EW, England.
(9) Zig-Zag Rule	Stanley	200 cm	\$ 2.69	Stanley Tools

Other Suppliers of Metric Tools:

Roe & Sons, Inc.
Patchogue, NY 11772
(Nos. 5,6,7,9)

L.S. Starrett Co.
Athol, MA
(No. 8)

Zelenda Machine & Tool Corp.
Metric Division
66-02 Austin Street
Forest Hills, NY 11374
(No. 2)

Section 2

GOING METRIC IN HOME ECONOMICS

GOING METRIC IN HOME ECONOMICS

NOTES AND COMMENTS

Consultant: Laurabelle Roderick

1. GOING METRIC IN THE USA. The United States is going metric even though at the present time there is no federal legislation for a planned and organized conversion program. The metric system has been the only legal system of measurement in the United States since 1866 when Congress passed a law outlining the use of metric measurements. However, it did not make the metric system compulsory. Most of the large multinational corporations are going metric even without federal legislation. The American National Metric Council is a private organization representing most of the large and small industries in the United States interested in metric conversion.
2. ISLANDS IN A METRIC WORLD. The United States, with its customary system of measurement, is virtually an island in a worldwide sea of metrication. Over 95% of the world's population lives in a metric country or in a country which is changing to the metric system.
3. KINDS OF MEASURING SYSTEMS.
4. THIS IS THE WAY THAT THE CUSTOMARY (ENGLISH) SYSTEM DEVELOPED. The customary system grew haphazardly without plan or order through regular usage. Our yard, inch and foot originally came from King Edgar of England in Anglo Saxon times. The

yard was the distance from the tip of the King's nose to the end of the middle finger of his outstretched arm. He decreed the inch to be the width of his thumb and the foot measure to be the length of his foot.

In contrast, an early standard for the metric system was based on the metre, which was originally defined as one ten-millionth of the distance between the pole and the equator.

5. INTERNATIONAL SYSTEM OF UNITS (SI). The fundamental building blocks of the SI metric system are the seven base units. Note that a symbol (not an abbreviation) is used to represent each unit. All symbols are in lower case letters except those named after famous scientists such as the ampere with a capital A.
6. PREFIX AND BASE UNITS. All base units use the same prefixes, exponents and symbols. The prefix used with each unit denotes the multiples and submultiples. The three measurements most commonly used are the base unit, one thousand times the base unit and one-thousandth of the base unit. For example, for length it would be the metre, kilometre and millimetre. Prefixes are not used alone. For example, kilo should not be used when referring to kilogram.
7. SI BASE UNITS--MOST IMPORTANT FOR EVERYDAY USE. The most frequently used base units in the consumer field are likely to be metre (m), kilogram (kg) and degree Celsius rather than kelvin.
8. SI DERIVED UNITS--MOST IMPORTANT FOR EVERYDAY USE. Derived units are compound units formed by algebraic combinations of base units, supplementary units and/or derived units. Many of

the derived units have special names such as degree Celsius, joule, newton and so forth. These units are named for the scientists whose work was largely responsible for the scientific use of the unit. There are other derived units without special names such as the square metre, cubic metre and litre. The litre is, for example, derived from the unit of length, the decimetre, and one cubic decimetre is exactly equal to one litre.

9. TEMPERATURE--CELSIUS SCALE. There are many tables of conversion factors to aid in the conversion from customary to metric units. Although sometimes necessary, mechanical conversion should not take the place of developing the individual's concept and familiarity of metric units and putting them to use in daily practice. For example, degree Celsius temperatures on the chart can be readily memorized for everyday needs.
10. METRICATION IN FOODS. Metric conversion in foods and nutrition will have a great affect on all aspects of food preparation and consumption. Food will be purchased in metric units and all cooking will be specified in metric units either by weight or volume. In commercial cookery weight will be used exclusively since it is more accurate.
11. BASIC MEASURING TOOLS FOR FOOD PREPARATION. Three basic metric tools can be used in food preparation. A gram scale will be used if ingredients are weighed; a measure marked in millilitres for measuring volume; and a set of smaller millilitre measures for convenience and accuracy in measuring small quantities.

12. THREE WAYS TO MEASURE INGREDIENTS--CUSTOMARY, METRIC BY VOLUME AND METRIC BY WEIGHT (MASS). Recipes will use a dual measuring system for some time. However, there are two ways to measure ingredients in the metric system--by volume and by weight (mass). It is not known at the present time which will be the preferred method.
13. COOKING MEASURES. When measuring ingredients by volume in a metric cup, it should be noted that the same volume of various ingredients has different weights (mass). For example, one metric cup of butter weighs or has a mass of 60 g more than one metric cup of flour.

Dual statements of quantity of ingredients giving both volume and weight (mass) in metric units could be listed in new recipes or reprints of old favorites.

14. POSSIBLE STANDARD MEASURES. Each of the present customary measures shown in the left-hand column, which are used in food preparation and service, can be given an exact (soft) conversion and a rounded (hard) conversion. It is the hard conversion which will eventually be the desired metric units.
15. BAKING UTENSIL SIZES. A very small size difference is shown between the metric soft conversion and the hard conversion. Since the metric sized utensils will be practically the same size as the utensils which are presently manufactured in customary measurements, the present household utensils can continue to be used for most recipes until replacement is necessary.

Metric utensil measurements in centimetres would seem

practical since unit sizes in millimetres are unwieldy.

16. BASIC MEASURE OF TEMPERATURE IS DEGREE CELSIUS. Degree Celsius measurement will replace Fahrenheit temperatures in food preparation. The degrees on the Celsius scale are exactly the same as the old centigrade scale that is no longer used.
17. Many liquid food items which are now purchased in pints, quarts and gallons will be sold in litres and submultiples of the litre. For example, a pint will be approximately 500 millilitres.
18. BASIC UNIT OF SMALL WEIGHTS IS THE GRAM. There are many food items which are presently labeled or weighed in ounces. The metric measurement for such items will be the gram. The hard conversion of rounded measurements will eventually replace the customary measurement units.
19. MANY GROCERY ITEMS ARE MARKED WITH BOTH CUSTOMARY (ENGLISH) AND METRIC WEIGHT. Cereal is only one of the many food items which are presently marked with dual measurements.
20. METRIC UNITS OF MEASUREMENT WILL BE SEEN ON MANY HOUSEHOLD ITEMS. Toothpaste is a common item used everyday that will probably be marked in millilitres as is now being done in Canada. Note that these are packaged in metric modules of rounded sizes. Since all brands will be packaged in exactly the same size, it will be easy for the consumer to compare prices.
21. BASIC UNIT OF LARGER WEIGHTS IS THE KILOGRAM. The kilogram is equal to 1000 grams or just over two pounds. Many food items will be purchased in kilograms. Pricing of the foods will be based on the kilogram. For example, 75¢ per kilogram is the

same price as 34¢ per pound.

22. METRICATION IN CLOTHING (TEXTILES AND NEEDLEWORK). Use of the metric system in clothing construction and purchasing is beginning to take affect in the United States. Like the people in many parts of the world we will be able to make and buy clothing the metric way.

American pattern, fabric and equipment companies who market products on an international scale will find it beneficial to be working with one measurement system and the consumer will benefit accordingly.

23. BASIC MEASURE OF LENGTH IS THE METRE. A metre is just over a yard or nearly forty inches. In manufacturing fabrics, industry will use centimetres for the width measurement of the fabric and metres for the length measurement.

24. AVAILABLE FABRIC WIDTHS. Fabric is now produced in a variety of widths expressed in inches. The widths would probably remain the same in metrication because of the costly investment of looms and other equipment set for particular widths. Only a conversion in terminology will be made with the width expressed in centimetres. The chart gives the customary and rounded metric measurement of present fabric widths. For example, 54 to 56 inch fabric will be measured as 140 centimetres.

25. METRIC FABRIC LENGTHS. In the purchasing of fabrics, a metre will probably be divided in 1/10's, 1/4's and 1/2's, which would be expressed in metres and centimetres as 1.10 m, 1.25 m and 1.50 m.

The smallest amount of fabric which can be purchased in the customary system is $\frac{1}{8}$ yard. In the metric system 10 centimetres will probably be the smallest length sold at one time.

The chart shown is similar to metric conversion charts which are beginning to appear in pattern books. To buy $3\frac{1}{4}$ yards of fabric in metric measurement, follow the horizontal line of 3 yards across to the vertical line of $\frac{1}{4}$ yard. The amount to purchase would be 3 metres.

26. RECOMMENDED INCHES TO MILLIMETRES AND CENTIMETRES. Many patterns for home dressmaking are already giving measurements in metric as well as customary units. For example, a $\frac{5}{8}$ " seam allowance can be marked as 1.5 cm or 15 mm. Listed here are customary and rounded metric conversions, which are often used in adjusting patterns, hem allowances and other construction details.

27. BASIC MEASURING TOOLS. Accurate measurement in dressmaking, fitting and altering is an important factor to insure that the garment fits the figure. Shown are the basic metric measuring tools, which are available at the present time in limited quantities. The hem marker, tape measure, metre stick and seam gauge are usually marked in centimetres. Millimetre units will also be marked on most of the basic tools although they will probably not be used as much.

The 60 inch tape measure will be replaced by a 150 centimetre tape; a yardstick will be replaced by a metre stick; a 6 inch hem gauge will be replaced by a 15 centimetre gauge;

and a 12 inch ruler could be replaced by a 30 centimetre ruler.

28. BODY MEASUREMENTS WILL BE IN CENTIMETRES. Occasionally metric body measurements might be taken or designated in millimetres, however, figure sizes in centimetres do not seem as unwieldy as when expressed in millimetres. For example, a waist measurement of 600 millimetres is almost impossible to comprehend.
29. SEWING NOTIONS. Some of the commonly used sewing notions are pictured here. Each is purchased in the customary system according to a particular measurement. At the present a few of the notions are dual marked by the manufacturer or importer.

The metric units of measurement for the lengths and widths shown here are hard conversions. This results in awkward numbers, therefore, some slight changes may have to be made to make use of rounded numbers possible. For example, 92 metres on the spool of thread might become 100 metres in the future.

The button industry will choose millimetres or centimetres to designate the size of the button.

Zippers will probably be manufactured in centimetres instead of inches. The correct size to purchase will eventually be listed on the pattern envelope.

30. MONDOPOINT SYSTEM OF SHOE SIZING. The mondopoint system of shoe sizing is intended to be an international system, which is an attempt to standardize shoe sizes.

The shoe size is made up of two numbers, the size and width index. On the chart the shoe size is written 240/95. The size number (240) is obtained by measuring the length of the foot in millimetres while the person is standing on that

foot. The width index number (95) indicates the fitting and is obtained by measuring the girth of the foot at the base of the toes. In this case, the measurement is 228 mm, which is 95% of 240.

With the mondopoint system it will make no difference where you buy your shoes, the size will remain the same.

31. CLOTHING WILL BE MANUFACTURED IN CENTIMETRES. Information on bust, waist and hip measurements will be used as the basis for sizing women's clothing. Manufacturers will probably be encouraged to adopt a uniform system of size designation such as 8, 10, 12, 14, etc. The garments shown in size 14 would be manufactured to fit the body measurements, which are shown with the skirt, dress and pants.

It is hoped that an international system of sizing clothing can be developed in the future in order to eliminate confusion among producers, distributors and users.

32. METRIC SHIRT SIZING. Conversion from the customary to the metric system of measurement in men's clothing will be easily accomplished since there are few problems relating to size and measurement in this area of clothing. The basic change will be from inches to centimetres. The two sets of measurements for shirt collar sizes are listed here. For example, customary size 15 will become 38 centimetres. Sleeve length will also be marked in centimetres.
33. NEEDLEWORK METRICS. The metric system for garment measurements, needle sizes and weight of yarn required will be used in knitting and crochet patterns. Already some knitting needles are

dual marked using millimetres to designate the diameter of the needles.

Balls of yarn used for knitting and crocheting will probably be marketed in quantities of 20 grams, 25 grams and 50 grams to replace the familiar 1 or 2 ounce balls. Twenty-five grams is slightly less than 1 ounce; therefore, if a pattern requires 1 ounce of yarn, it would be necessary to purchase two 20 gram or two 25 gram balls of yarn.

It is very important for home economists and consumers to build an awareness of the metric system of measurement and to understand how the conversion will affect our daily lives. An early exposure to the metric system will help to eliminate unnecessary confusion. An understanding of the metric system will help accomplish a smoother and more organized transition from customary to metric.

Although there are some areas where metric standards are not available at the present time, the measuring system has been established and will be fundamental in our society in the years to come.

All You Will Need to Know About Metric

(For Your Everyday Life)

10

Metric is based on Decimal system

The metric system is simple to learn. For use in your everyday life you will need to know only ten units. You will also need to get used to a few new temperatures. Of course, there are other units which most persons will not need to learn. There are even some metric units with which you are already familiar: those for time and electricity are the same as you use now.

BASIC UNITS

- METER:** a little longer than a yard (about 1.1 yards)
LITER: a little larger than a quart (about 1.06 quarts)
GRAM: about the weight of a paper clip

(comparative sizes are shown)



25 DEGREES FAHRENHEIT

COMMON PREFIXES

(to be used with basic units)

- Milli:** one-thousandth (0.001)
Centi: one-hundredth (0.01)
Kilo: one-thousand times (1000)

For example:

- 1000 millimeters = 1 meter
 100 centimeters = 1 meter
 1000 meters = 1 kilometer

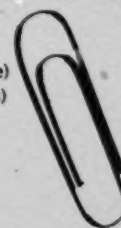
1 LITER

1 QUART



OTHER COMMONLY USED UNITS

- | | |
|--------------------------------|---|
| Millimeter: 0.001 meter | diameter of paper clip wire |
| Centimeter: 0.01 meter | width of a paper clip (about 0.4 inch) |
| Kilometer: 1000 meters | somewhat further than 1/2 mile (about 0.6 mile) |
| Kilogram: 1000 grams | a little more than 2 pounds (about 2.2 pounds) |
| Milliliter: 0.001 liter | five of them make a teaspoon |

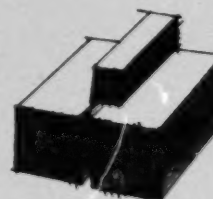
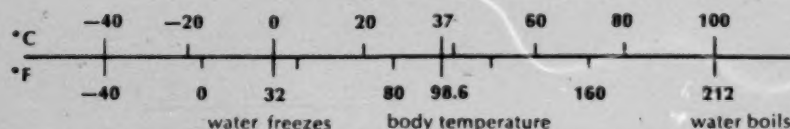


OTHER USEFUL UNITS

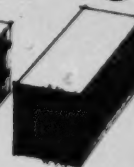
- Hectare:** about 2 1/2 acres
Tonne: about one ton

TEMPERATURE

degrees Celsius are used



1 KILOGRAM

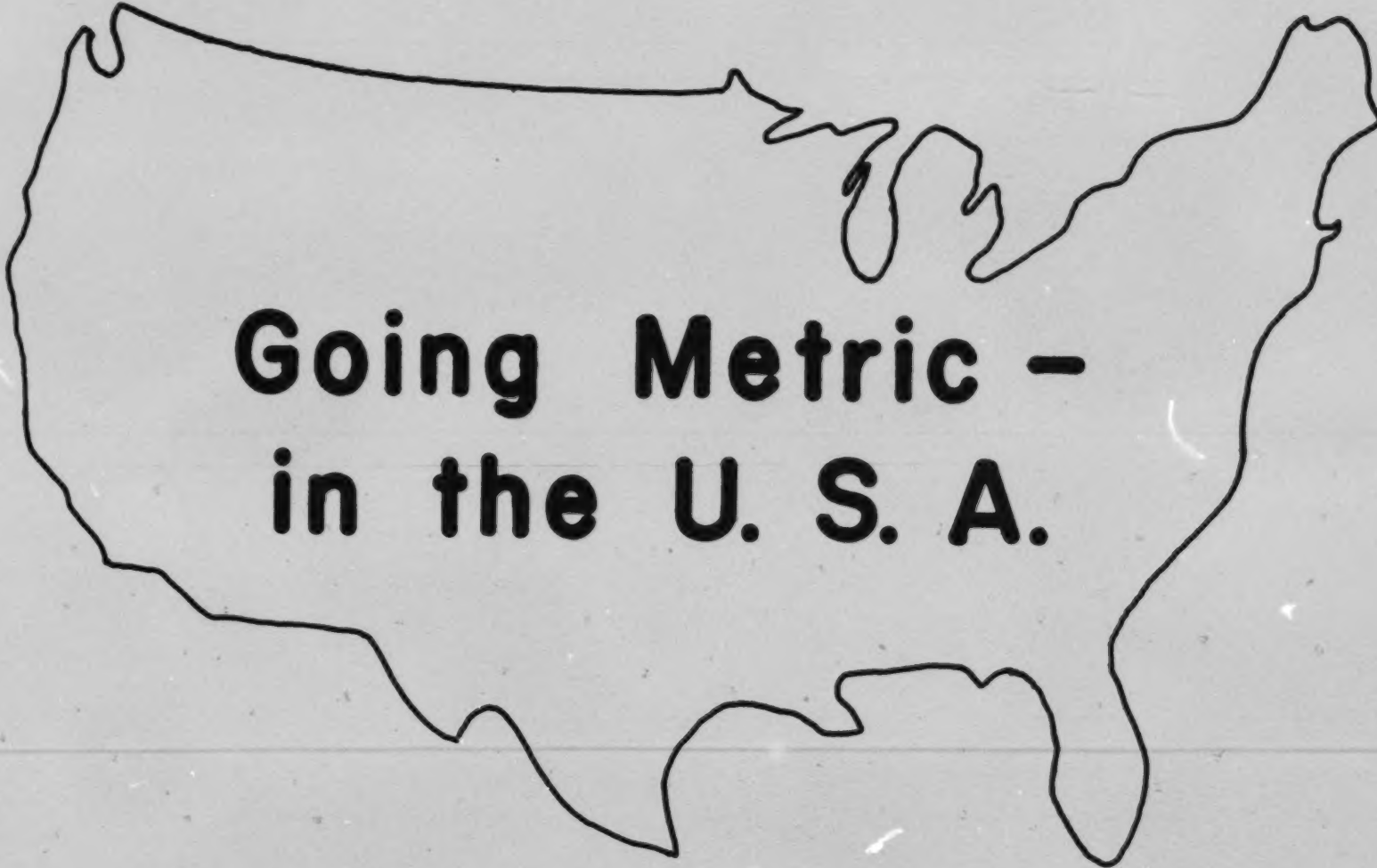


1 POUND

For more information, write to: Metric Information Office, National Bureau of Standards
 Washington, D.C. 20234

Note: This chart may be reproduced





Going Metric - in the U. S. A.

398

399



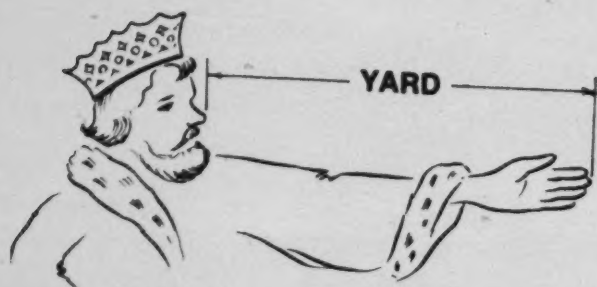


Kinds of Measuring Systems

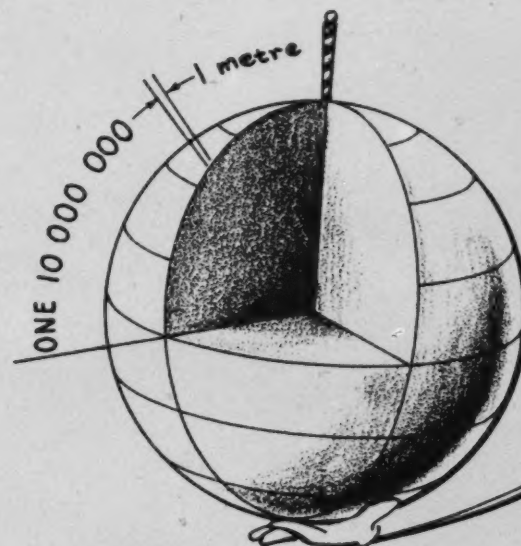
- 1. Customary*
- 2. Metric*
- 3. SI Metric*



THIS IS THE WAY THAT
THE CUSTOMARY (ENGLISH)
SYSTEM DEVELOPED.



403



The metre
is equal to
 $\frac{1}{10,000,000}$ of
the distance from
the north pole
to the equator.



404



INTERNATIONAL SYSTEM OF UNITS

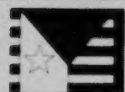
SI

SEVEN BASE UNITS - SYMBOL - MEASUREMENT

<i>1. metre</i>	<i>m</i>	<i>Length</i>
<i>2. kilogram</i>	<i>kg</i>	<i>Mass</i>
<i>3. second</i>	<i>s</i>	<i>Time</i>
<i>4. ampere</i>	<i>A</i>	<i>Electric Current</i>
<i>5. kelvin</i>	<i>K</i>	<i>Temperature</i>
<i>6. candela</i>	<i>cd</i>	<i>Luminous Intensity</i>
<i>7. mole</i>	<i>mol</i>	<i>Amount of Substance</i>



PREFIX & BASE UNIT	VALUES
kilometre	1 000. m
hectometre	100.0 m
dekametre	10.0 m
metre	1.0 m
decimetre	0.1 m
centimetre	0.01 m
millimetre	0.001 m



SI BASE UNITS

MOST IMPORTANT FOR EVERYDAY USE

metre

m = length, area, volume

25.4 mm = 1 inch

m = 1.1 yards

km = 0.6 miles

kilogram

kg = mass, not weight

(weight=force=newtons)

kg = 2.2 pounds

28 g = 1 ounce

tonne = 2200 pounds

kelvin

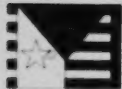
K = temperature

Use degrees Celsius (°C)

Do not use centigrade

°F = °C × 1.8 then add 32

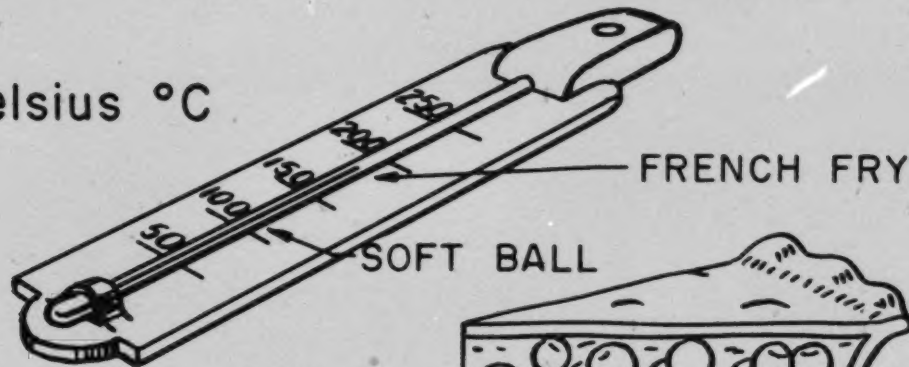
°C = (°F - 32) × 0.56



SI DERIVED UNITS

MOST IMPORTANT FOR EVERYDAY USE

degree Celsius °C



joule J

1 Calorie =
4.2 kilojoules



355 Calories =
1491 kilojoules

litre ℓ

1 cubic decimetre =
1 litre



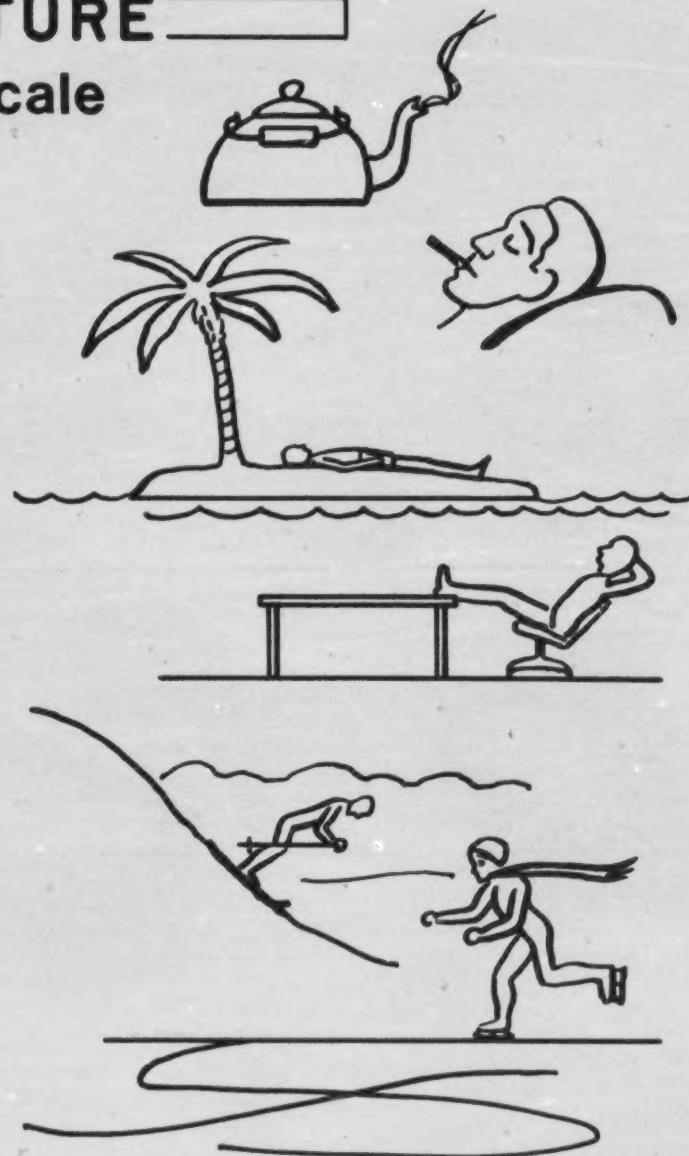
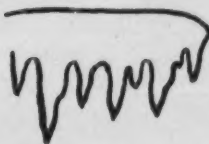
1 litre =
1.06 quarts



TEMPERATURE

Celsius Scale

100	Boiling Point (water)
40	High Fever
37	Normal Body Temperature
30	Quite Warm
22	Air Conditioned Building
20	Mild Spring Day
10	Warm Winter Day
5	Skiing
0	Freezing
-5	Icicles
-30	Bitter Cold





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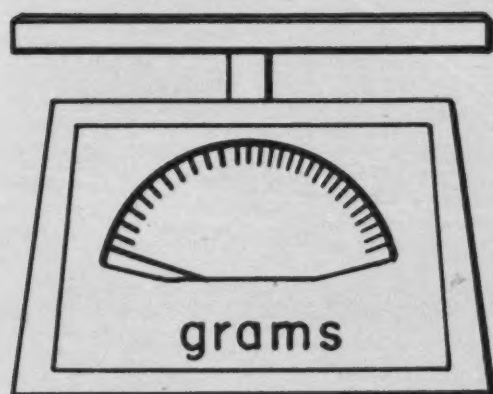
Metrication in Foods

415

416



Basic measuring tools for food preparation



15 ml

5 ml

2.5 ml

1.25 ml





3 ways to measure ingredients :

customary — metric — metric
by volume by weight (mass)

SPONGE CAKE

1 1/4 cups sifted cake flour
1/4 cup sugar
1/4 teaspoon salt
1 teaspoon cream of tartar
5 large eggs, separated
1/4 cup sugar
3/4 cup light or dark corn syrup
1/2 teaspoon vanilla
1/2 teaspoon lemon extract

SPONGE CAKE

300 millilitres sifted cake flour
60 millilitres sugar
1.25 millilitres salt
5 millilitres cream of tartar
5 large eggs, separated
60 millilitres sugar
180 millilitres light or dark corn syrup
2.5 millilitres vanilla
2.5 millilitres lemon extract

SPONGE CAKE

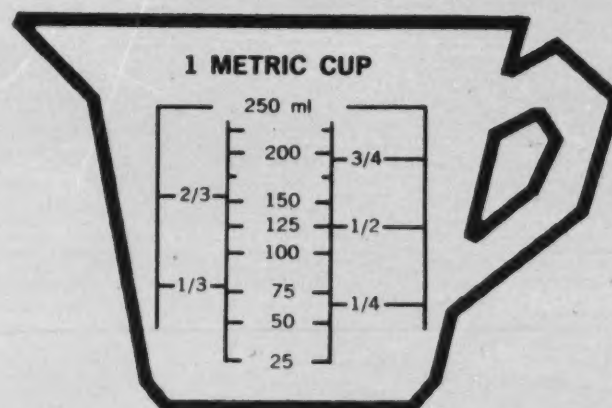
120 grams cake flour
50 grams sugar
1.5 grams salt
3 grams cream of tartar
5 large eggs, separated
50 grams sugar
180 millilitres light or dark corn syrup
2.5 millilitres vanilla
2.5 millilitres lemon extract

420



COOKING MEASURES

<u>METRIC CUP</u>	<u>VOLUME (LIQUID)</u>	<u>LIQUID SOLIDS (BUTTER)</u>	<u>FINE POWDER (FLOUR)</u>	<u>GRANULAR (SUGAR)</u>	<u>GRAIN (RICE)</u>
1	250 ml	200 g	140 g	190 g	150 g
3/4	188 ml	150 g	105 g	143 g	113 g
2/3	167 ml	133 g	93 g	127 g	100 g
1/2	125 ml	125 g	70 g	95 g	75 g
1/3	83 ml	67 g	47 g	63 g	50 g
1/4	63 ml	50 g	35 g	48 g	38 g
1/8	31 ml	25 g	18 g	24 g	19 g





POSSIBLE STANDARD MEASURES

customary

exact conversion
soft conversion

rounded metric
hard conversion

1 quart

946 ml

1 000 ml

1 pint

473.2 ml

500 ml

1 cup

236.6 ml

250 ml

1 Tbsp

14.8 ml

15 ml

1 tsp

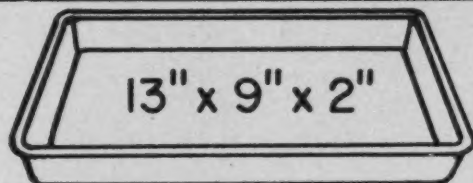
4.9 ml

5 ml

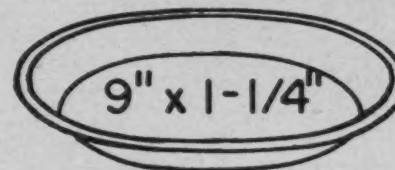


Baking Utensil Sizes

Utensil	U. S. Customary Units Inches	Equivalent in Metric Units Centimetres	Metric Units Rounded Centimetres
<u>Cake Pans</u>			
Oblong	13 x 9 x 2	33.0x22.9x5.1	33 x 23 x 5
Round	8 x 1-1/2	20.3 x 3.8	20 x 4
Square	8 x 8 x 2	20.3x20.3x5.1	21 x 21 x 5
<u>Pie Pans or Plates</u>			
	8 x 1-1/4	20.3 x 3.2	20 x 3
	9 x 1-1/4	22.9 x 3.2	23 x 3



Approx. 330 x 230 x 50 mm
33 x 23 x 5 cm



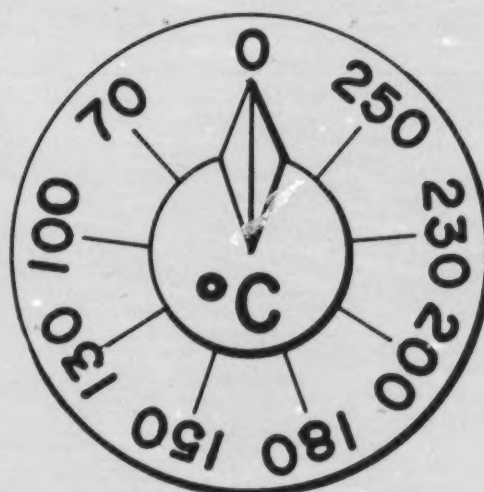
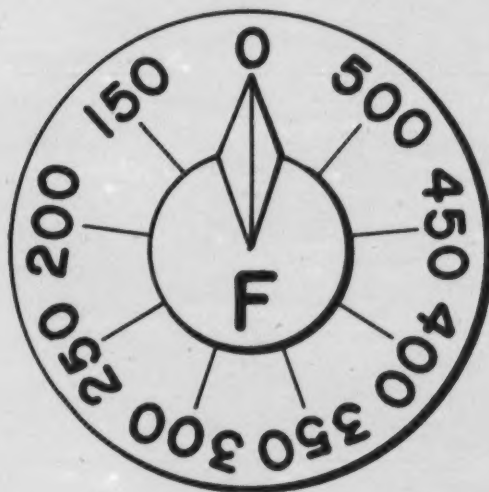
Approx. 229 x 32 mm
23 x 3 cm



CENTER FOR METRIC EDUCATION • WESTERN MICHIGAN UNIVERSITY

Basic measure of temperature is [] degree Celsius []

Fahrenheit degree Celsius



250° to 300°—Low—130° to 150°
350°—Moderate— 180°
425° to 450°—Hot—220° to 230°

OVEN THERMOSTAT
MARKINGS

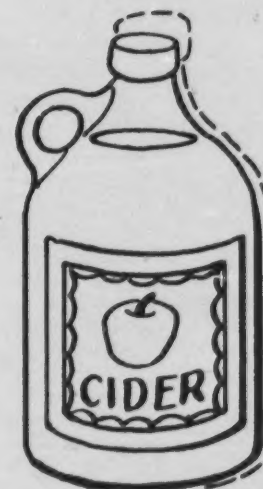
Recommended Conversion degree Celsius	Present Scale Fahrenheit
70 °C	150 °F
80 °C	175 °F
100 °C	200 °F
110 °C	225 °F
130 °C	250 °F
140 °C	275 °F
150 °C	300 °F
170 °C	325 °F
180 °C	350 °F
190 °C	375 °F
200 °C	400 °F
220 °C	425 °F
230 °C	450 °F
240 °C	475 °F
250 °C	500 °F
270 °C	525 °F
290 °C	550 °F



Basic liquid measure is the
litre



500 millilitres =
1.06 pints



4 litres =
1.06 gallons

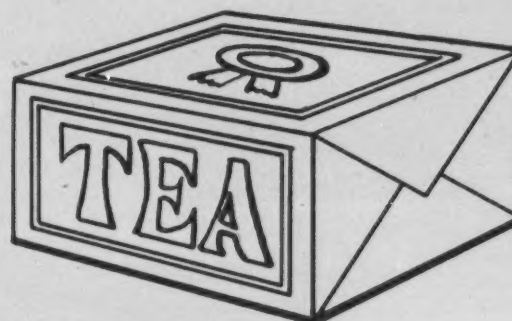
one litre = 1.06 quarts



Basic unit of small weights is the

gram

453.6 grams = 1 pound
28.35 grams = 1 ounce } **EXACT**

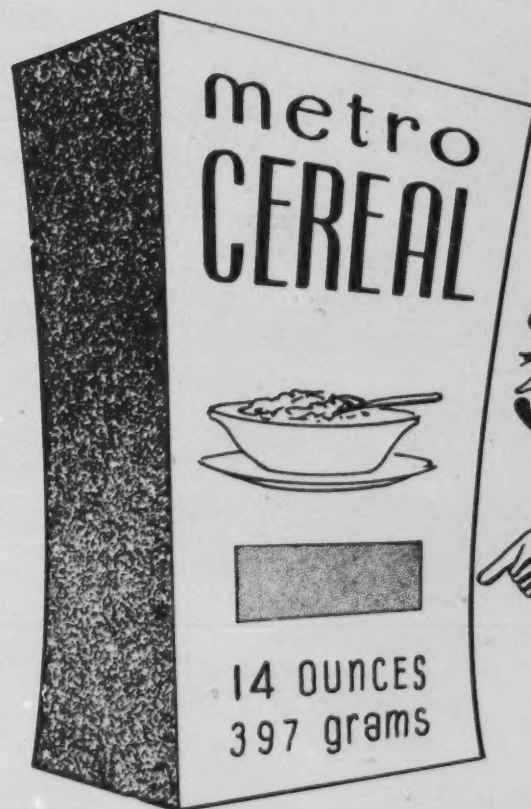


Possible rounded conversions

28 grams	to replace	1 ounce
125 grams	to replace	1/4 pound
250 grams	to replace	1/2 pound
500 grams	to replace	1 pound

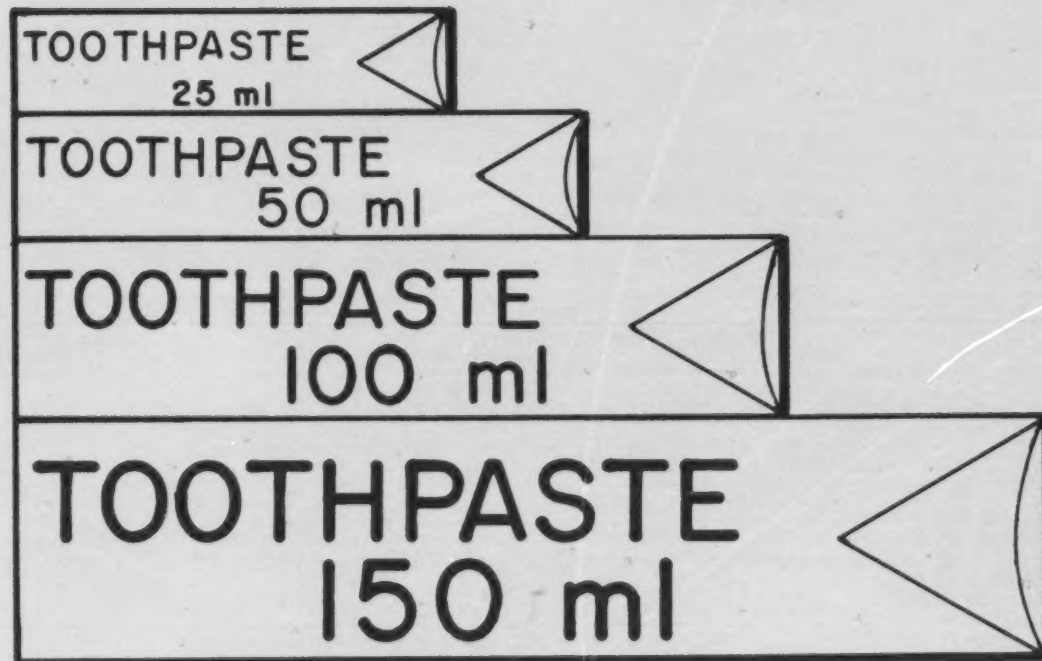


**Many GROCERY ITEMS
are marked with both
customary (English)
and metric weight.**





Metric units of measurement will be seen on many **HOUSEHOLD ITEMS**

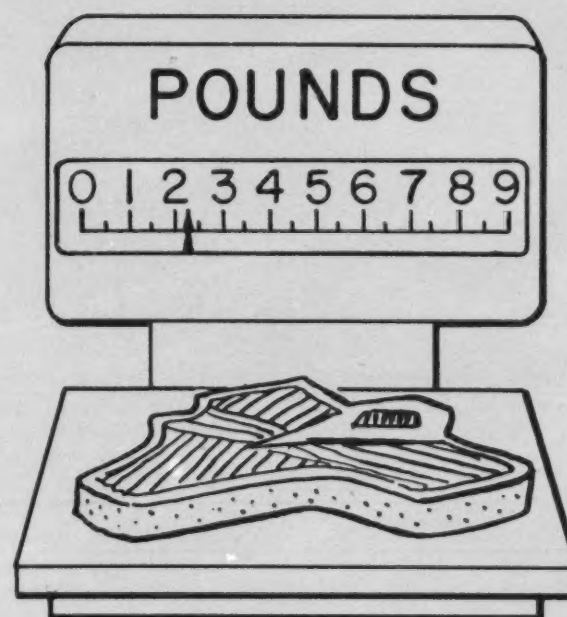
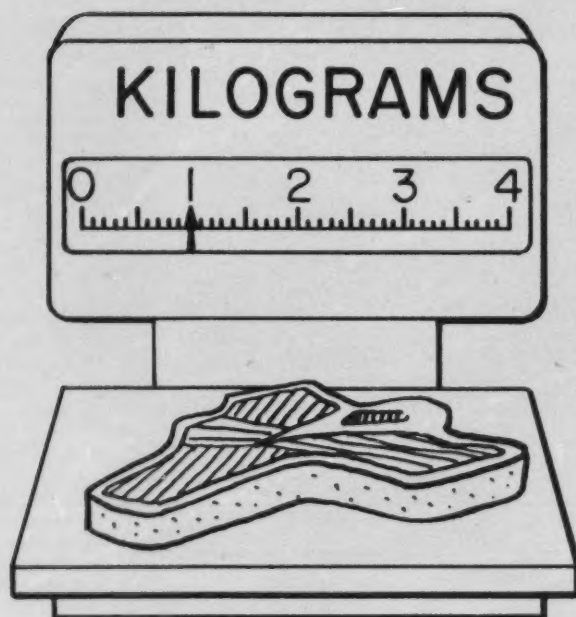




Basic unit of larger weights is

kilogram

0.45 kilogram = 1 pound



Possible conversion

1 kilogram to replace 2 pounds.



Metrication in Clothing

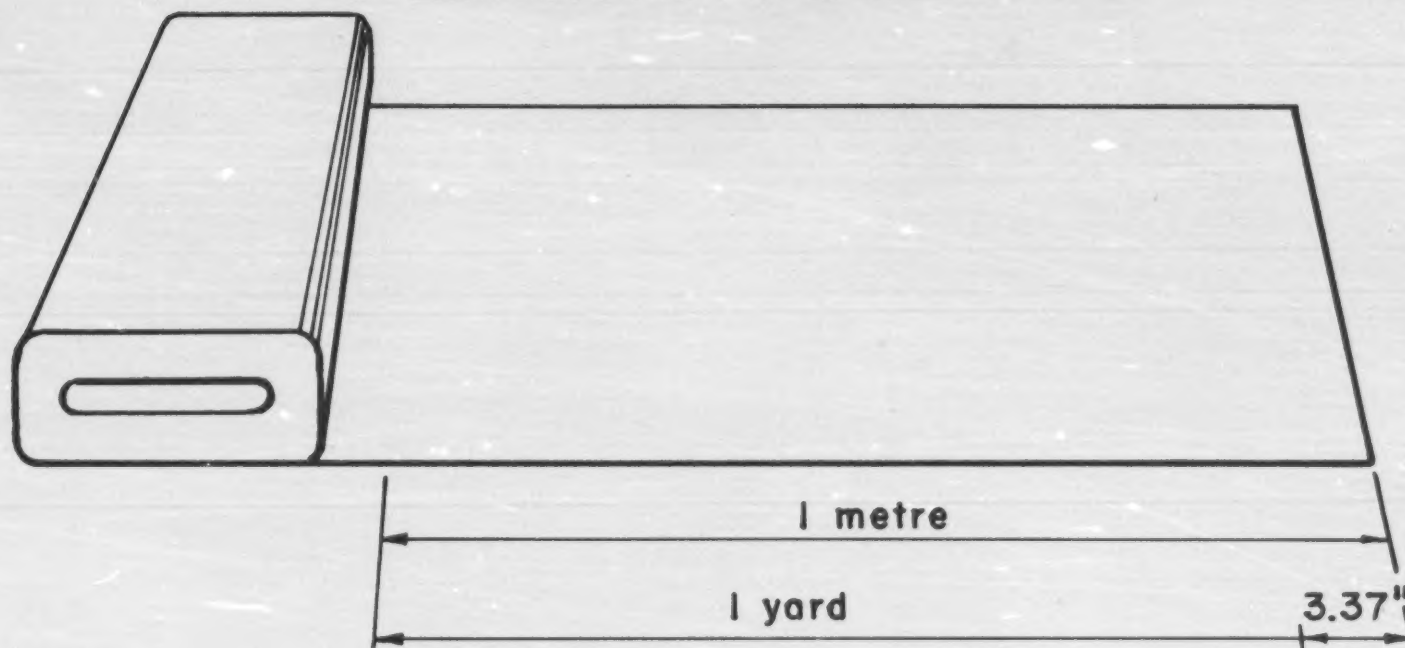
(Textiles and Needlework)

439

440



Basic measure of length is the
 metre



WIDTH:

Cloth width will be measured in centimetres.

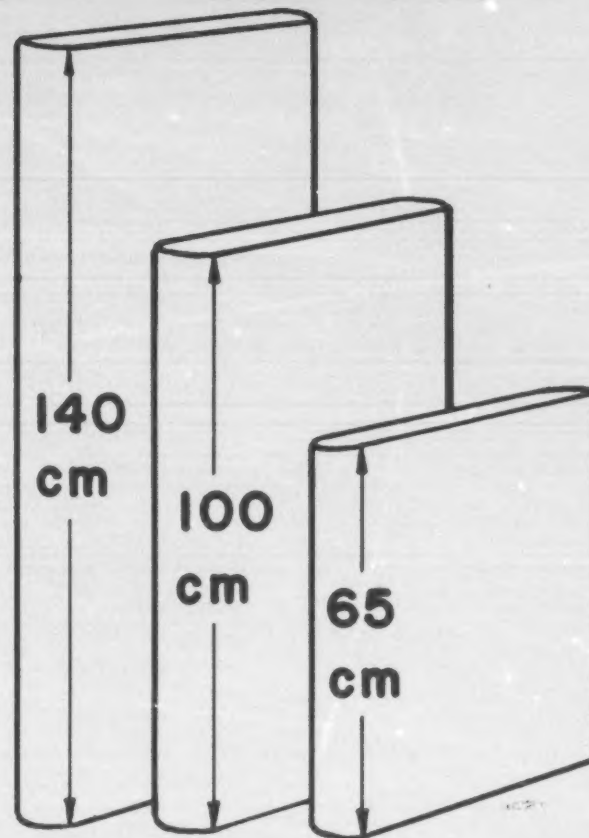
LENGTH:

Cloth length will be measured in metres.



Available Fabric Widths

Customary	Metric
Inches	Centimetres
25	65
27	70
35 - 36	90
39	100
44 - 45	115
48	122
50	127
54 - 56	140
58 - 60	150
68 - 70	175
72	180



(Approximate Conversion)
as approved by the
Pattern Fashion Industry.



□ Metric Fabric Lengths □

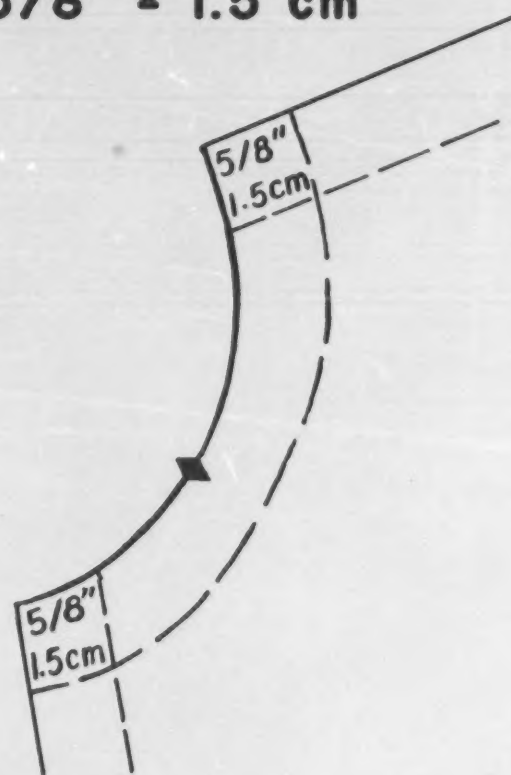
	Yds.	1/8	1/4	3/8	1/2	5/8	3/4	7/8
	metres	0.15	0.25	0.35	0.50	0.60	0.70	0.80 m
1 yard	0.95	1.05	1.15	1.30	1.40	1.50	1.60	1.75 m
2 yards	1.85	1.95	2.10	2.20	2.30	2.40	2.55	2.65 m
3 yards	2.75	2.90	3.00	3.10	3.20	3.35	3.45	3.55 m
4 yards	3.70	3.80	3.90	4.00	4.15	4.25	4.35	4.50 m
5 yards	4.60	4.70	4.80	4.95	5.05	5.15	5.30	5.40 m
6 yards	5.50	5.60	5.75	5.85	5.95	6.10	6.20	6.30 m



Recommended inches to millimetres and centimetres chart

inches	mm	cm
1/8	3	.3
1/4	6	.6
3/8	10	1.
1/2	13	1.3
5/8	15	1.5
3/4	20	2.0
7/8	22	2.2
1	25	2.5
1-1/4	32	3.2
1-1/2	38	3.8
1-3/4	45	4.5
2	50	5

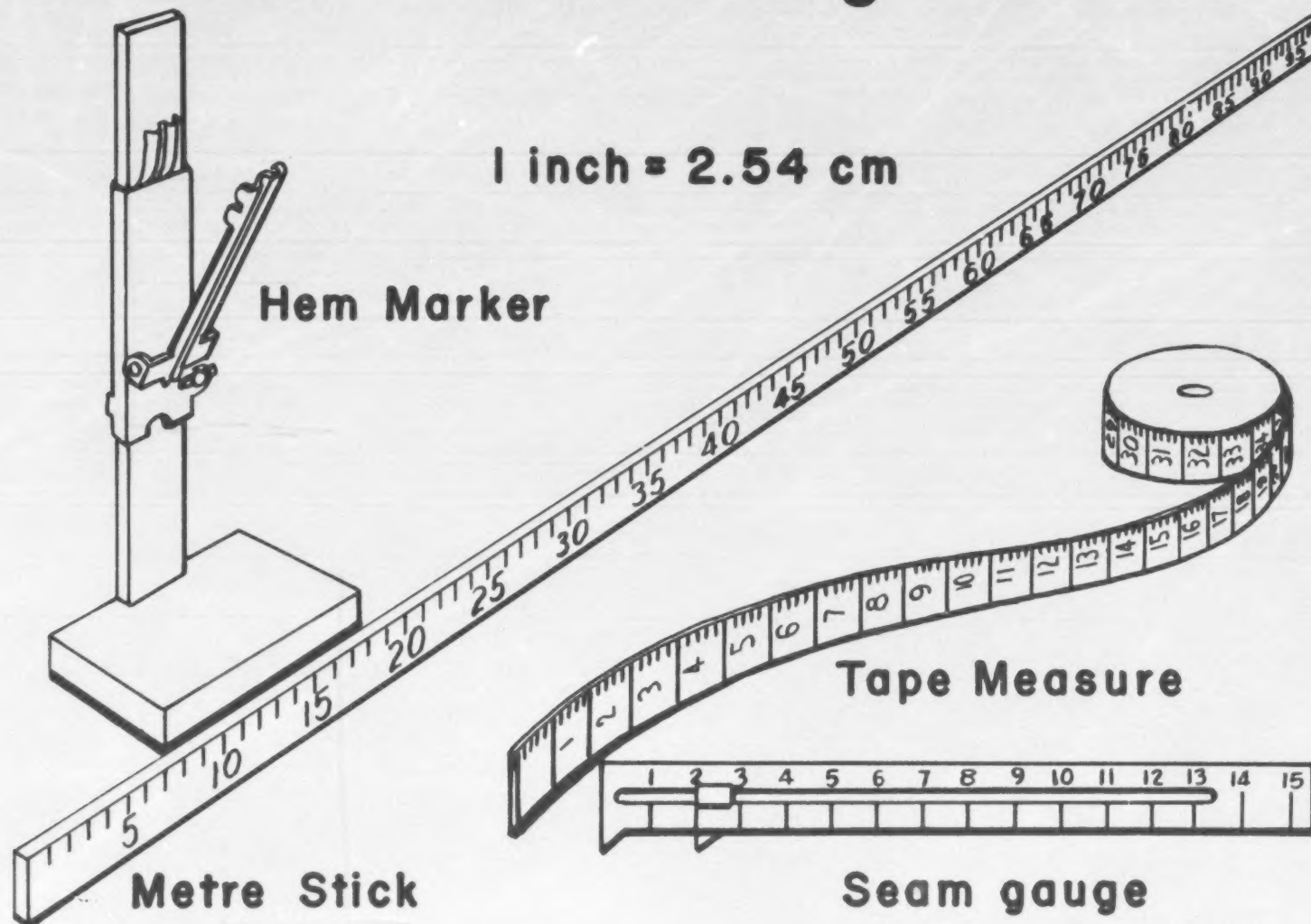
Seam allowances of
 $5/8" = 1.5 \text{ cm}$





□ Basic measuring tools □

1 inch = 2.54 cm





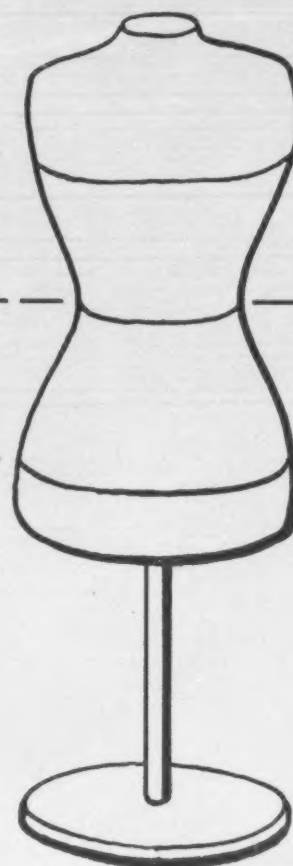
Body measurements will be in centimetres

Customary
Measurement

36" ———

24" ———

36" ———



Metric
Measurement

90 cm

60 cm

90 cm



Sewing Notions

(Approximate Metric Conversions)



Yards	Metres
100	92
352	322
Thread	



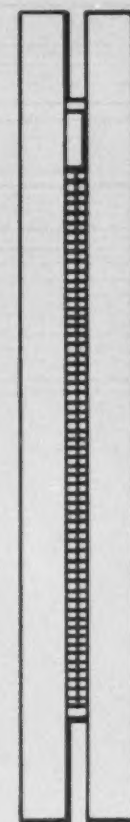
Inches	mm
7/16	6



5/8	13
-----	----



1	25
Buttons	



Inches	cm
7	18
12	30
18	45

Zippers

454



□ Mondopoint System □

of shoe sizing



Size is indicated by the length.

Width index indicates the fitting.

Example: Length = 240 mm

Girth = 228 mm

228 = 95 % of 240

Requires a shoe marked

240/95

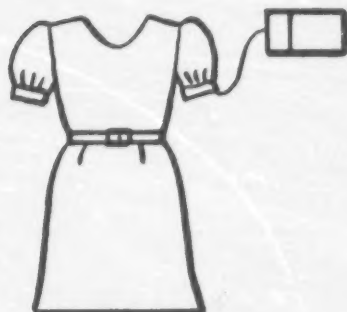
456



Clothing will be manufactured in Centimetres



Size	To fit
14	Waist 72 cm
	Hip 102 cm



Size	To fit
14	Bust 92 cm
≡	Waist 72 cm
	Hip 102 cm



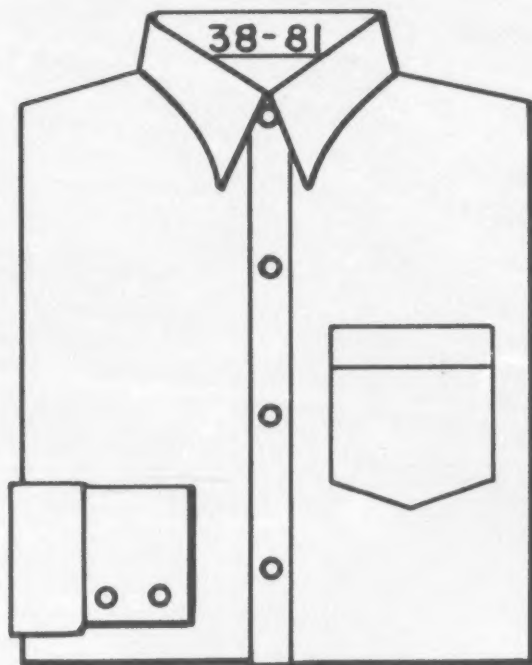
Size	To fit
14	Waist 72 cm
	Hip 102 cm



□ Metric shirt sizing □

Collar
Size
38

Sleeve
Length
81



Collar sizes	
Customary Inches	Metric Centimetres

13	33
13-1/2	34-35
14	36
14-1/2	37
15	38
15-1/2	39-40
16	41
16-1/2	42
17	43
17-1/2	44-45



NEEDLEWORK METRICS



Knitting Needle Measurements

Customary Number	Metric (millimetres)
00	2
1	2.5
5	4
7	5
9	6
10	6.5
11	7.5
12	8



Some Present Label Measurements

Customary	Metric
4 ounces	114 grams
3.6 ounces	100 grams
1.5 ounces	40 grams



METRIC EQUIPMENT LIST FOR HOME ECONOMICS

Item	Manufacturer	Size/Capacity	Purchase Price	Purchased From
Kitchen Scale	Dr. Oetker (West Germany)	1 000 g	\$ 9.00 (approx.)	Gesellschaft mbH & Co. Bielefelder StraBe 125 D-4812 Brackwede West Germany
Cookery Thermometer	Brannan Company (England)	20 °C - 260 °C	\$11.50	Dick Blick Company P.O. Box 1267 Galesburg, IL 61401
Measuring Spoons	(Sweden)	1, 5, 15 ml	\$ 1.25	Seabon, Inc. 54 E. 54th Street New York, NY 10022
Think Metric Bath Scale	Brealey Scale Co. (U.S.A.)	135 kg	\$ 9.95	Swani Publishing Co. Box 248 Roscoe, IL 61073
Cylindrical Measure	Efi, Inc. (West Germany)	various	\$ 1.30	The Pepper Mill 6039 S. Westnedge Ave. Kalamazoo, MI 49002
Multi-Measure Cup	Foley Company (U.S.A.)	500 ml	\$.98	Department Stores Housewares Department
Mini-Max Pin-It Skirt Marker	Orco Products, Inc. (U.S.A.)	----	\$ 3.00	Fabric/Sewing Stores
Sewing Patterns	Simplicity Pattern Company (U.S.A.)	----	\$ 1.00	Fabric/Sewing Stores

METRIC EQUIPMENT LIST FOR HOME ECONOMICS, p. 2

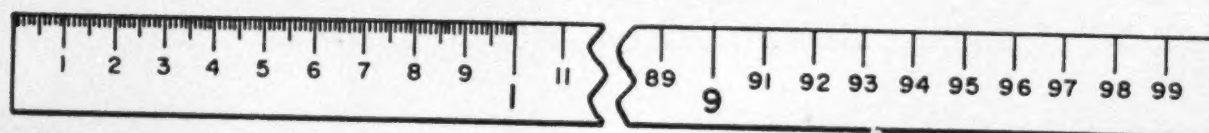
Item	Manufacturer	Size/Capacity	Purchase Price	Purchased From
Embroidery Thread	Mettler Company (Switzerland)	322 m	\$.59	Fabric/Sewing Stores
Sewing Thread	Molnlycke Company (Sweden)	110 m	\$.35	Fabric/Sewing Stores
Metre Stick	The Cooper Group (U.S.A.)	1 m	\$ 2.76	The Cooper Group P.O. Box 728 Apex, NC 27502
Seam Gauge	Singer Company (U.S.A.)	15 cm	\$.40	Fabric/Sewing Stores
Tape Measure	Scovill Mfg. Co. (England)	150 cm	\$.40	Fabric/Sewing Stores
Pie Plate	Corning Glass Works (U.S.A.)	22.9 x 32 cm	\$.89	Department Stores Housewares Department

Section 3

SAMPLES OF INSTRUCTIONAL MATERIAL USED DURING INDEPTH
METRIC SEMINAR, COLORADO STATE UNIVERSITY

Review of Length Measurement

Look at this picture, and then complete the statements listed below.

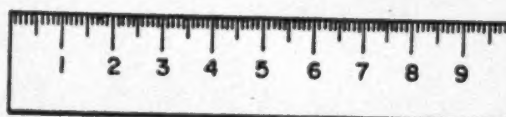


BASE UNIT

1 metre m

one tenth metre

$1/10$ m or 0.1 m



1 decimetre dm

one hundredth metre

$1/100$ m or 0.01 m



1 centimetre cm

one thousandth metre

$1/1000$ m or 0.001 m



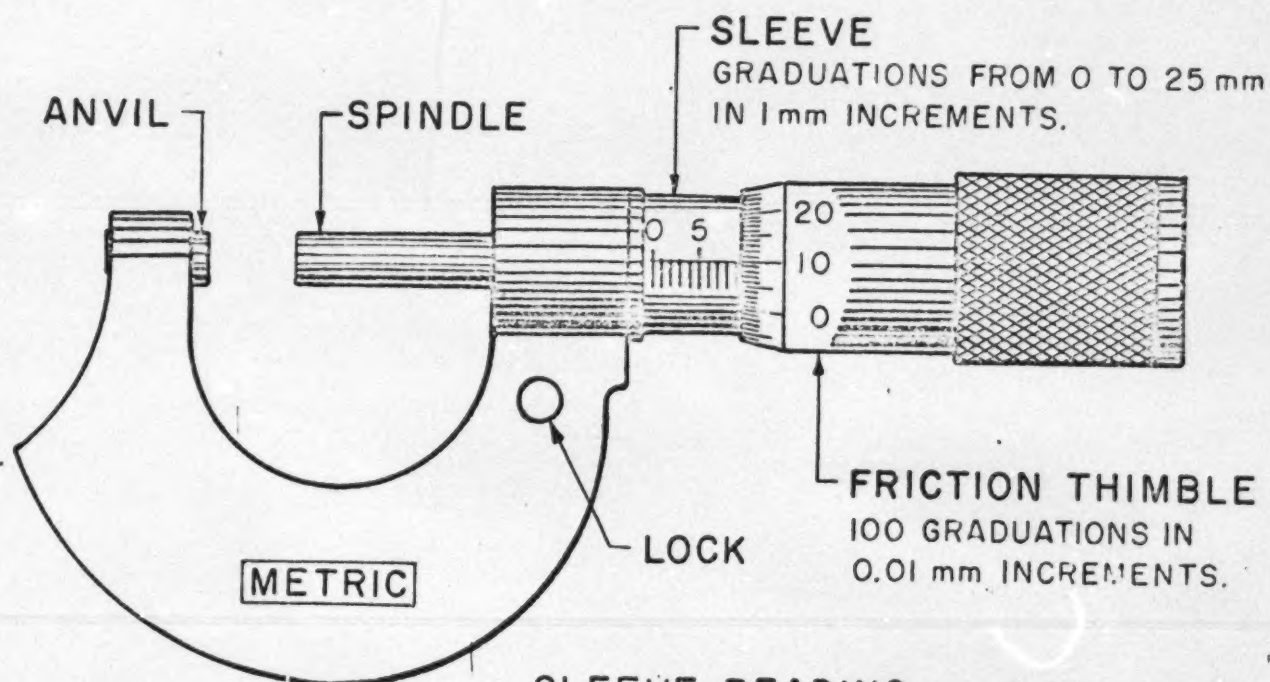
1 millimetre mm

1. The base unit for length in the metric system is the _____.

Answer to Frame 1 metre

2. The symbol for the word metre is _____.

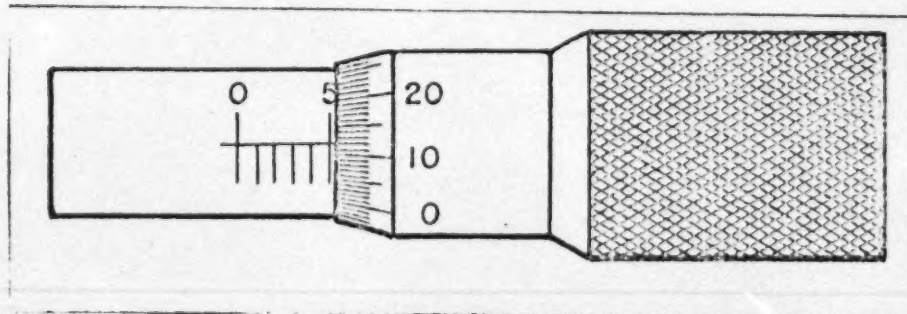
STRAIGHT READING METRIC MICROMETER



SLEEVE READING	9.00 mm
THIMBLE READING	0.10 mm
	<u>9.10 mm</u>

(No answer required; go to the next frame)

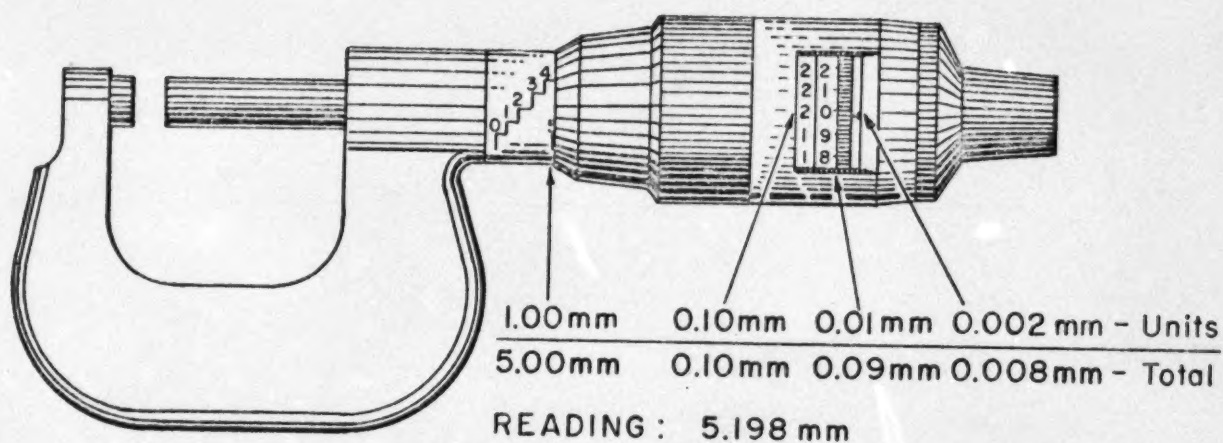
The reading below shows _____ millimetres.



Part C - Direct Reading on Spindle and Thimble Micrometer

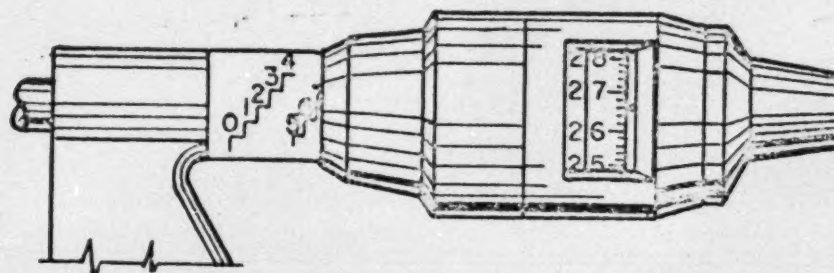
32. This direct reading metric micrometer reads to an accuracy of 0.002 millimetre (two thousandths of a millimetre) equal to about 0.00008 inch (eight hundred thousandths). First, read the full millimetres on the sleeve. Then read the thimble. The first number on the thimble represents tenths, the second number hundredths and the lines between the numbers each represent 0.002 mm. Next, total the results. Look at the reading below. (1) The sleeve shows a reading of 5.00 mm. (2) The thimble shows a reading of 0.198 mm.

METRIC MICROMETER TYPE 2 - READING ON SPINDLE AND DIRECT READING THIMBLE



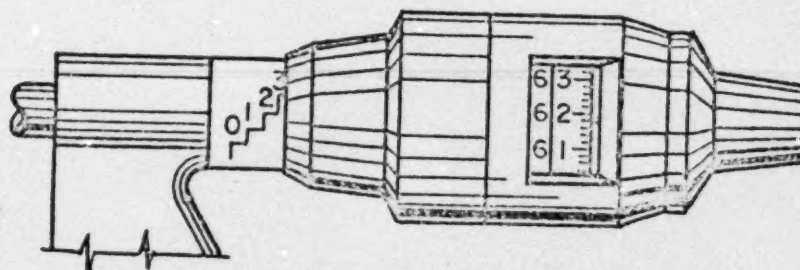
(No answer required; go to the next frame)

The reading below shows _____ millimetres.



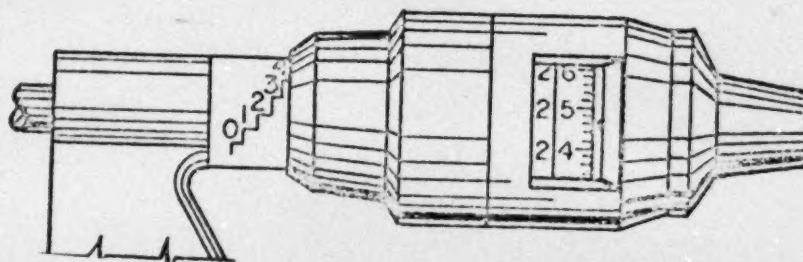
Answer to Frame 33 7.266 mm

The reading below shows _____ millimetres.

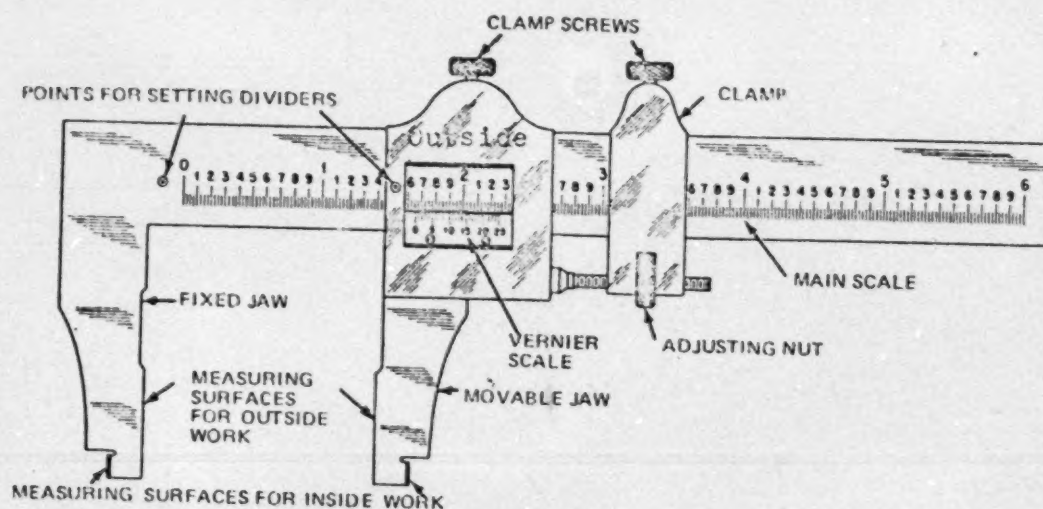


Answer to Frame 34 3.618 mm

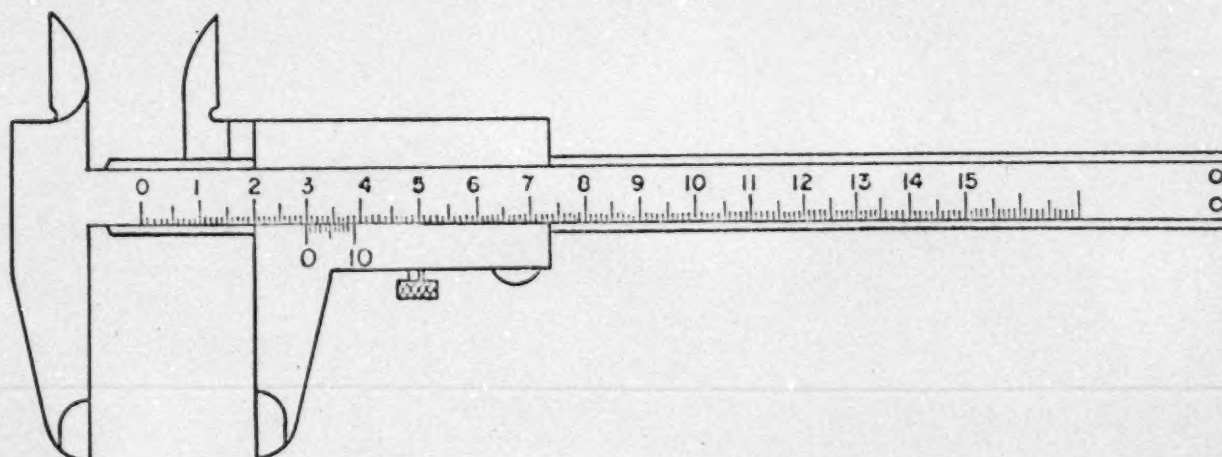
The reading below shows _____ millimetres.



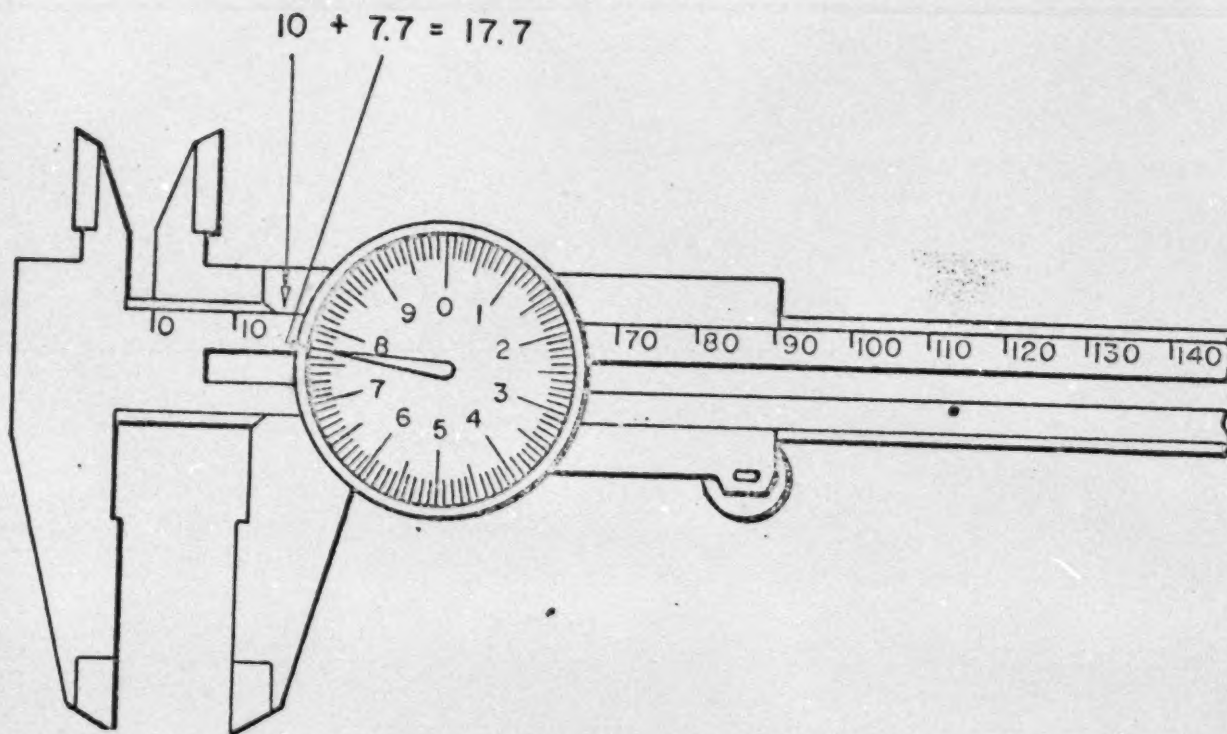
vernier from the side marked inside. In other words, read outside measurements from one side and inside measurements from the other side of the vernier caliper.



2. T-shaped vernier caliper. Use the lower jaws for outside (external) measurements and the upper jaws for inside (internal) measurements. Make either reading on the same scale.



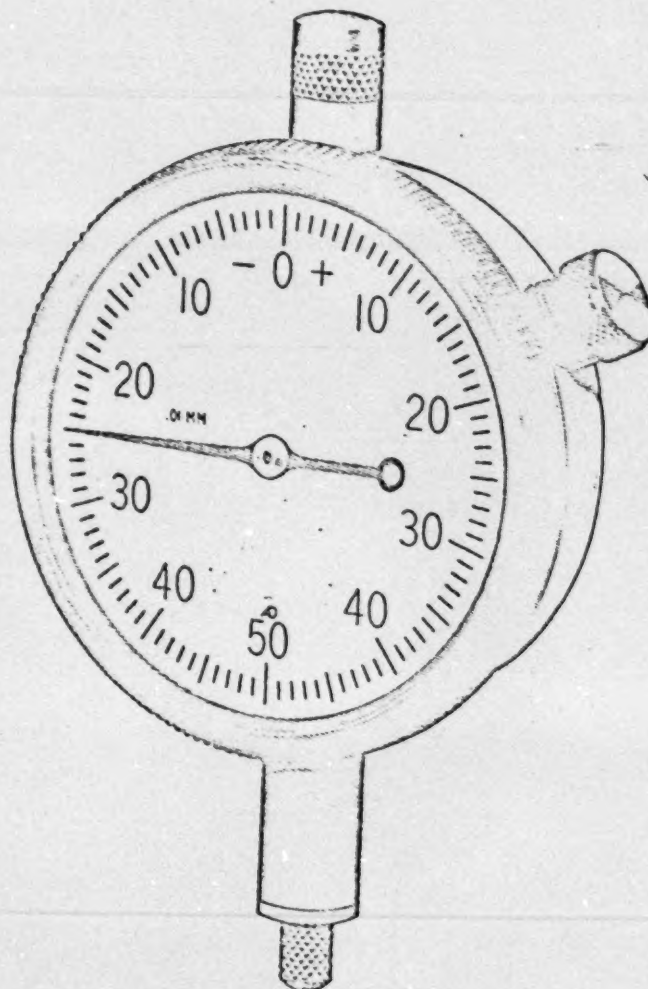
38. E. Vernier caliper with dial face. There are various kinds of vernier calipers in which the vernier scale is a dial. The dial divides a division on the main scale into equal parts. The vernier caliper below has a dial face that divides 10 millimetres on the main scale into millimetres and tenths of a millimetre. The total reading is 17.7 mm.



Before using a dial indicator, select the correct type and range. The balance type always has readings showing a plus or minus from the zero. The continuous type reads in a clockwise direction from zero to 1 mm for one revolution. This registers on the inner scale up to a maximum of 10 mm.

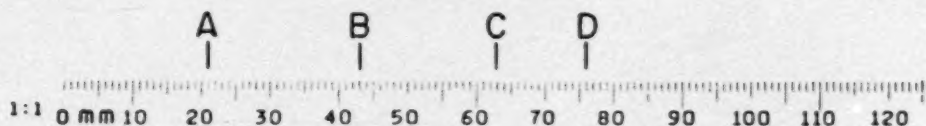
(No answer required; go to the next frame)

2. The dial indicator below is the _____ type.



A drafting scale is used to measure or lay out the length of a line. The scale may be full size, smaller than full size or larger than full size. These scales are referred to as 1:1, reduction, and enlargement respectively. For example, a reduction scale would be used to draw a locomotive wheel, while an enlargement scale would be used to draw an alarm clock wheel.

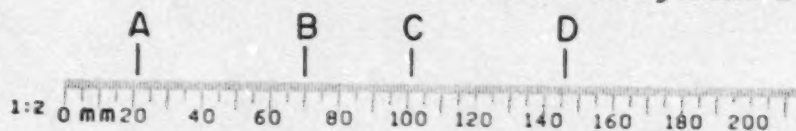
Since the metric system is based on units of 10, all metric drafting scales have a factor of 10 relationship. All metric drafting scales should be marked with the numbered lines in millimetres, not centimetres. The typical drafting scale is 300 millimetres long. Never use a metric drafting scale marked in centimetres since this can only cause difficulty and confusion. The millimetre scale is easy to read. A full size (1:1) scale is shown below.



1. The dimensions shown on the scale above are:

- A. _____ millimetres
- B. _____ millimetres
- C. _____ millimetres
- D. _____ millimetres

The scale below can be used as a 5:1 enlargement scale.



The dimensions (for 5:1 enlargement) on the scale shown above are:

A. _____ millimetres

B. _____ millimetres

C. _____ millimetres

D. _____ millimetres

Answer to Frame 12 A. 2.1 mm

B. 7.0 mm

C. 10.1 mm

D. 14.6 mm

13. The actual size of the smallest division is _____ millimetre.

Answer to Frame 13 0.5 mm

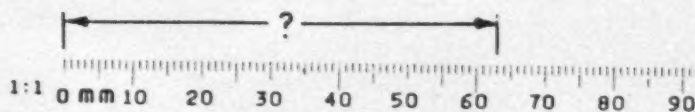
14. The 1:5 reduction scale can be used as a 2:1 (double size) enlargement scale. Again these scales differ by a factor of ten. Simply drop off the zero of each numbered line of the reduction scale 1:5 to use it as a 2:1 enlargement scale. For example, in using the 1:5 reduction scale, the distance marked zero to 100 millimetres would become zero to 10 millimetres. The smallest readable division would be 0.5 millimetre (one-half millimetre).

Second Side

1:2 reduction (0.5 mm) } first scale
1:5 reduction (1 mm) }
3 1/3:1 enlargement (2/3 mm) } second scale
10:1 enlargement (1 mm) }

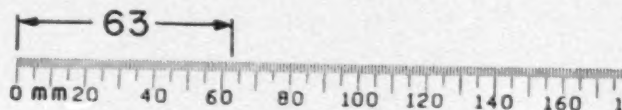
No answer required; go to the next frame.

17. The missing dimension on this full size illustration is _____ millimetres.



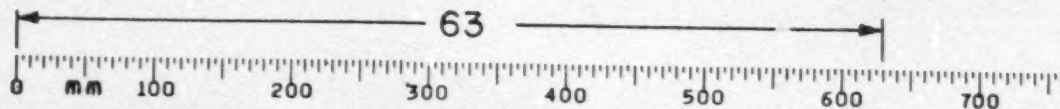
Answer to Frame 17 63 mm

18. The reduction scale in this illustration is ____:____.



Answer to Frame 18 1:2

19. The enlargement scale in this illustration is ____:____.



Answer to Frame 19 2:1

20. The reduction scale used to make the above enlargement illustration is ____:____.

19. All angular dimensions are expressed in degrees (this is true even though the radian is the SI metric unit for plane angles). Decimal parts of a degree should be used in preference to minutes and seconds. An included angle of $60^{\circ} 30'$ should be shown as _____.
-

Answer to Frame 19 60.5°

20. The symbol $\varnothing$ should precede the diameter dimension (or use DIA after the dimension) and use an R before the radius dimension. A hole that is twenty-four millimetres in diameter should be dimensioned with a symbol as _____.
-

Answer to Frame 20 $\varnothing 24$

21. Tapers should be expressed in terms of a ratio. A taper of twenty-five hundredths per one millimetre should be shown as _____.
-

Answer to Frame 21 Taper $0.25:1$

22. Limits and fits will be expressed in current U.S. standards. There is an ISO standard for limits and fits, however, this

INCHES INTO MILLIMETERS

Inches	Metric	Inches	Metric	Inches	Metric	Inches	Metric	Inches	Metric	Inches	Metric	Inches	Metric
Decimals		Fractions											
0.001	0.0254	1/16	2.54	1/8	3.175	1/4	6.35	3/8	9.525	1/2	12.7	3/4	19.05
0.002	0.0508	1/8	3.175	3/16	4.7625	1/4	6.35	5/16	7.9375	3/8	9.525	7/16	11.1125
0.003	0.0762	1/4	6.35	1/4	6.35	1/2	12.7	3/4	19.05	1	25.4	1 1/4	31.75
0.004	0.1016	5/16	7.9375	5/16	7.9375	3/4	19.05	1	25.4	1 1/4	31.75	1 3/4	38.1
0.005	0.1270	3/8	9.525	3/8	9.525	1	25.4	1 1/4	31.75	1 3/4	38.1	2	50.8
0.006	0.1524	1/2	12.7	1/2	12.7	1 1/4	31.75	1 3/4	38.1	2	50.8	2 1/4	61.275
0.007	0.1778	5/8	15.875	5/8	15.875	1 3/4	38.1	2	50.8	2 1/4	61.275	2 3/4	68.575
0.008	0.2032	3/4	19.05	3/4	19.05	2	50.8	2 1/4	61.275	2 3/4	68.575	3	76.2
0.009	0.2286	7/8	22.225	7/8	22.225	2 1/4	61.275	2 3/4	68.575	3	76.2	3 1/4	85.725
0.010	0.254	1	25.4	1	25.4	2 3/4	68.575	3	76.2	3 1/4	85.725	3 1/2	89.175
0.020	0.508	1 1/16	28.225	1 1/16	28.225	3	76.2	3 1/4	85.725	3 1/2	89.175	3 3/4	95.225
0.030	0.762	1 1/8	31.75	1 1/8	31.75	3 1/4	85.725	3 3/4	95.225	4	101.6	4 1/4	110.325
0.040	1.016	1 1/4	31.75	1 1/4	31.75	3 3/4	95.225	4	101.6	4 1/4	110.325	4 1/2	114.3
0.050	1.270	1 3/8	34.9375	1 3/8	34.9375	4	101.6	4 1/4	110.325	4 1/2	114.3	4 3/4	119.375
0.060	1.524	1 1/2	38.1	1 1/2	38.1	4 1/4	110.325	4 1/2	114.3	4 3/4	119.375	5	127.0
0.070	1.778	1 5/8	39.6875	1 5/8	39.6875	4 3/4	119.375	5	127.0	5 1/4	136.525	5 1/2	139.7
0.080	2.032	1 3/4	41.275	1 3/4	41.275	5	127.0	5 1/4	136.525	5 1/2	139.7	5 3/4	144.275
0.090	2.286	1 7/8	44.4375	1 7/8	44.4375	5 1/4	136.525	5 1/2	139.7	5 3/4	144.275	6	152.4
0.100	2.540	2	50.8	2	50.8	5 3/4	144.275	6	152.4	6 1/4	160.025	6 1/2	162.675
0.110	2.794	2 1/8	54.0125	2 1/8	54.0125	6	152.4	6 1/4	160.025	6 1/2	162.675	6 3/4	167.725
0.120	3.048	2 1/4	61.275	2 1/4	61.275	6 1/4	160.025	6 1/2	162.675	6 3/4	167.725	7	177.8
0.130	3.302	2 3/8	59.6875	2 3/8	59.6875	6 3/4	167.725	7	177.8	7 1/4	186.075	7 1/2	188.725
0.140	3.556	2 1/2	63.5	2 1/2	63.5	7	177.8	7 1/4	186.075	7 1/2	188.725	7 3/4	194.775
0.150	3.810	2 5/8	65.1375	2 5/8	65.1375	7 1/4	186.075	7 1/2	188.725	7 3/4	194.775	8	203.2
0.160	4.064	2 3/4	68.575	2 3/4	68.575	7 3/4	194.775	8	203.2	8 1/4	211.925	8 1/2	214.575
0.170	4.318	2 7/8	71.1375	2 7/8	71.1375	8	203.2	8 1/4	211.925	8 1/2	214.575	8 3/4	219.625
0.180	4.572	3	76.2	3	76.2	8 1/4	211.925	8 1/2	214.575	8 3/4	219.625	9	228.6
0.190	4.826	3 1/8	76.2	3 1/8	76.2	8 3/4	219.625	9	228.6	9 1/4	236.875	9 1/2	239.525
0.200	5.080	3 1/4	82.55	3 1/4	82.55	9	228.6	9 1/4	236.875	9 1/2	239.525	9 3/4	244.575
0.210	5.334	3 3/8	85.1125	3 3/8	85.1125	9 1/4	236.875	9 1/2	239.525	9 3/4	244.575	10	254.0
0.220	5.588	3 1/2	89.175	3 1/2	89.175	9 3/4	244.575	10	254.0	10 1/4	262.125	10 1/2	264.775
0.230	5.842	3 5/8	91.7375	3 5/8	91.7375	10	254.0	10 1/4	262.125	10 1/2	264.775	10 3/4	269.825
0.240	6.096	3 3/4	95.225	3 3/4	95.225	10 1/4	262.125	10 1/2	264.775	10 3/4	269.825	11	279.3
0.250	6.350	3 7/8	98.7875	3 7/8	98.7875	10 3/4	269.825	11	279.3	11 1/4	287.375	11 1/2	290.025
0.260	6.604	4	101.6	4	101.6	11	279.3	11 1/4	287.375	11 1/2	290.025	11 3/4	295.075
0.270	6.858	4 1/8	104.1375	4 1/8	104.1375	11 1/4	287.375	11 1/2	290.025	11 3/4	295.075	12	304.8
0.280	7.112	4 1/4	110.325	4 1/4	110.325	11 3/4	295.075	12	304.8				
0.290	7.366	4 3/8	111.9375	4 3/8	111.9375								
0.300	7.620	4 1/2	114.3	4 1/2	114.3								
0.310	7.874	4 5/8	116.8375	4 5/8	116.8375								
0.320	8.128	4 3/4	119.375	4 3/4	119.375								
0.330	8.382	4 7/8	121.9375	4 7/8	121.9375								
0.340	8.636	5	127.0	5	127.0								
0.350	8.890	5 1/8	129.5375	5 1/8	129.5375								
0.360	9.144	5 1/4	136.525	5 1/4	136.525								
0.370	9.400	5 3/8	139.075	5 3/8	139.075								
0.380	9.654	5 1/2	141.6	5 1/2	141.6								
0.390	9.908	5 5/8	144.1375	5 5/8	144.1375								
0.400	10.162	5 3/4	146.675	5 3/4	146.675								
0.410	10.416	5 7/8	149.225	5 7/8	149.225								
0.420	10.670	6	152.4	6	152.4								
0.430	10.924	6 1/8	154.9375	6 1/8	154.9375								
0.440	11.178	6 1/4	160.025	6 1/4	160.025								
0.450	11.432	6 3/8	162.575	6 3/8	162.575								

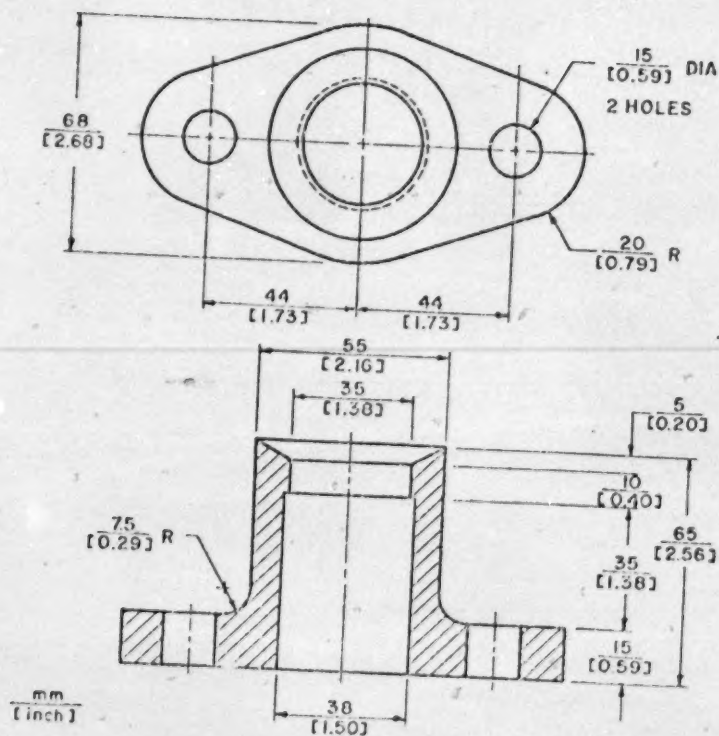
COMMON METRIC EQUIVALENTS AND CONVERSIONS

APPROXIMATE Common Equivalents	ACCURATE Conversion to Parts Per Million	APPROXIMATE Common Equivalents	ACCURATE Conversion to Parts Per Million
1 inch = 25.4 millimeters	inches x 25.4 = millimeters	1 millimeter = 0.04 inch	millimeters x 0.039 370 1 = inches
1 foot = 0.3 meter	feet x 0.3048 = meters	1 meter = 3.3 feet	meters x 3.280 84 = feet
1 yard = 0.9 meter	yards x 0.9144 = meters	1 meter = 1.1 yards	meters x 1.093 61 = yards
1 mile = 1.6 kilometers	miles x 1.609 34 = kilometers	1 kilometer = 0.6 mile	kilometers x 0.621 371 = miles
1 square inch = 6.5 square centimeters	sq inches x 6.4516 = square centimeters	1 square centimeter = 0.16 square inch	sq centimeters x 0.155 000 = square inches
1 square foot = 0.09 square meter	sq feet x 0.092 903 0 = square meters	1 square meter = 11 square feet	sq meters x 10.763 9 = square feet
1 square yard = 0.8 square meter	sq yards x 0.836 127 = square meters	1 square meter = 1.2 square yards	sq meters x 1.195 99 = square yards
1 acre = 0.4 hectare	acres x 0.404 686 = hectares	1 hectare = 2.5 acres	hectares x 2.471 05 = acres
1 cubic inch = 16 cubic centimeters	cu inches x 16.3871 = cubic centimeters	1 cubic centimeter = 0.06 cubic inch	cu centimeters x 0.061 023 7 = cubic inches
1 cubic foot = 0.03 cubic meter	cu feet x 0.028 316 8 = cubic meters	1 cubic meter = 35 cubic feet	cu meters x 35.314 7 = cubic feet
1 cubic yard = 0.8 cubic meter	cu yards x 0.764 555 = cubic meters	1 cubic meter = 1.3 cubic yards	cu meters x 1.307 95 = cubic yards
1 quart (liq) = 1 liter	quarts (liq) x 0.946 353 = liters	1 liter = 1 quart (liq)	liters x 1.056 69 = quarts (liq)
1 gallon = 0.004 cubic meter	gallons x 0.003 785 41 = cubic meters	cu meters x 264.172 = gallons	cu meters x 264.172 = gallons
1 ounce (avdp) = 28 grams	oz (avdp) x 28.349 5 = grams	grams x 0.035 274 0 = ounces (avdp)	grams x 0.035 274 0 = ounces (avdp)
1 pound (avdp) = 0.45 kilogram	lbs (avdp) x 0.453 592 = kilograms	1 gram = 0.0022 pounds (avdp)	grams x 2.204 62 = pounds (avdp)
1 horsepower = 0.75 kilowatt	hp x 0.745 700 = kilowatts	1 kilowatt = 1.3 horsepower	kilowatts x 1.341 02 = horsepower

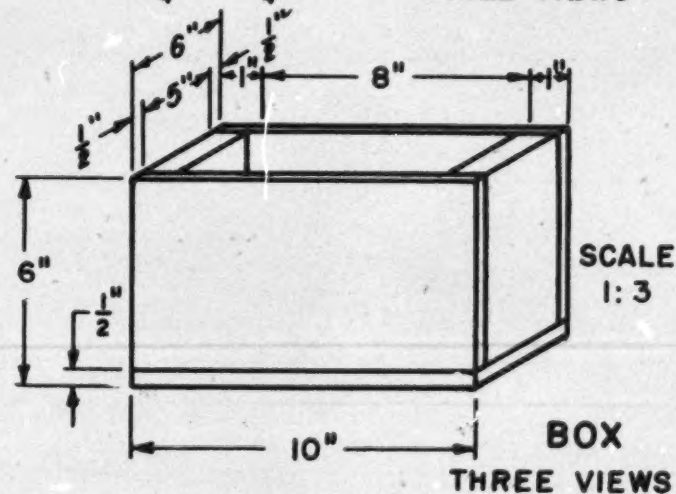
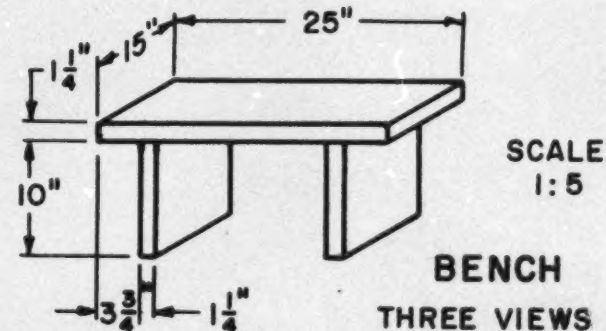
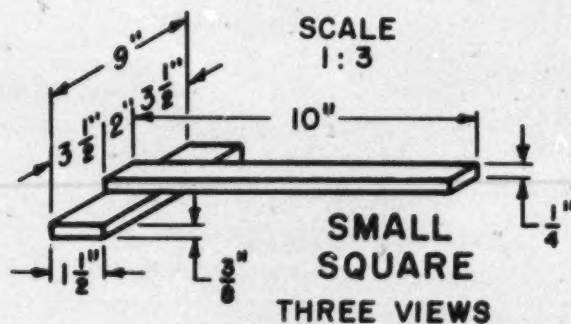
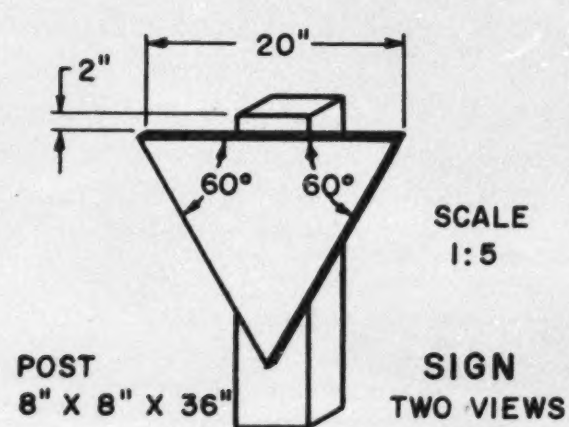
†Common term not used in SI. *Exact.

26. Answer the following questions concerning this dual dimensioned drawing:

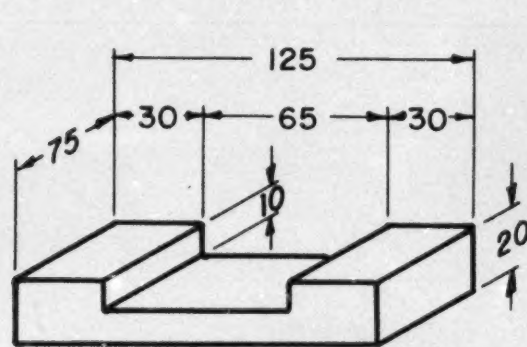
- A. The overall height is _____ millimetres.
- B. The overall width is _____ inches.
- C. The diameter of the bolt holes is _____ millimetres.



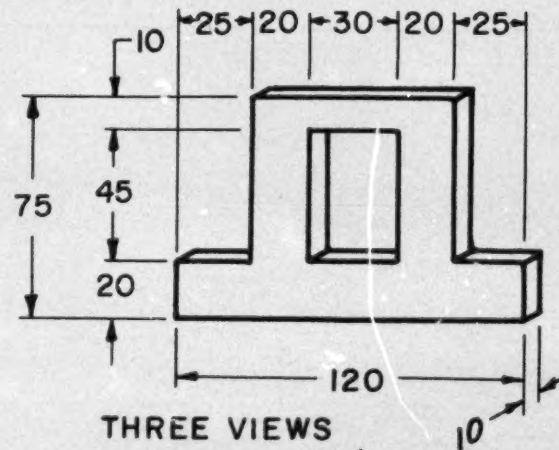
MAKE MULTI-VIEW DRAWINGS, USING THE REDUCTION SCALE SHOWN. CONVERT ALL MEASUREMENTS TO mm AND ROUND TO THE FULL MILLIMETRE. ADD DIMENSIONS.



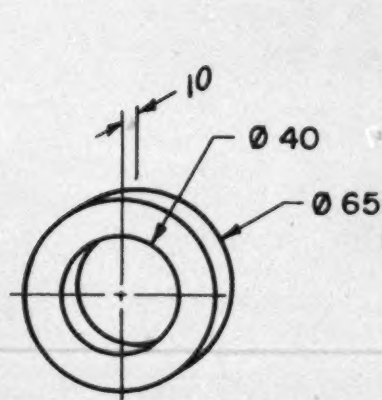
MAKE MULTI-VIEW SKETCHES (SCALE 1:1)
ADD DIMENSIONS



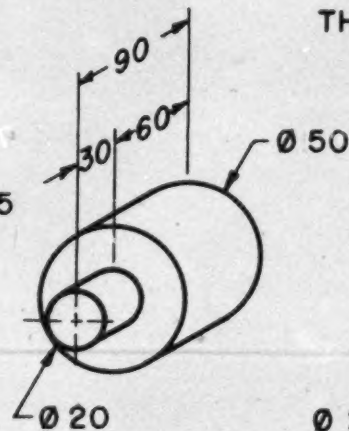
THREE VIEWS



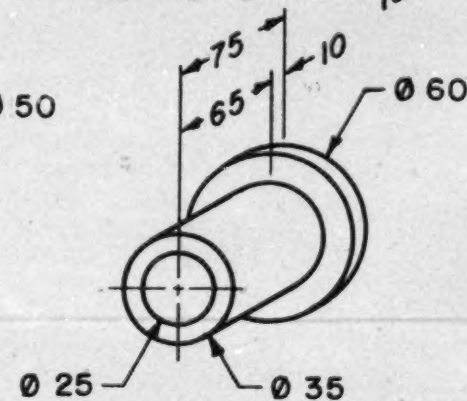
THREE VIEWS



TWO VIEWS



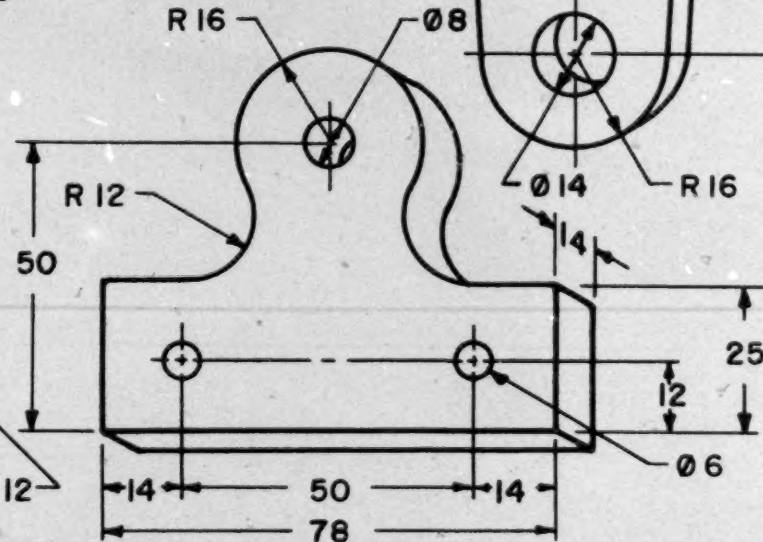
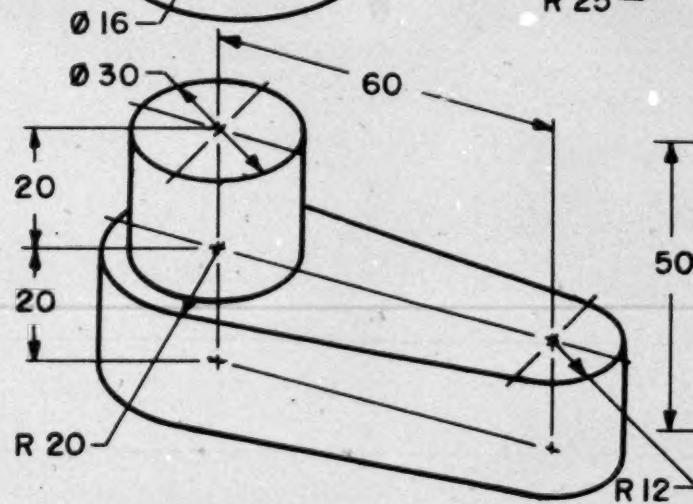
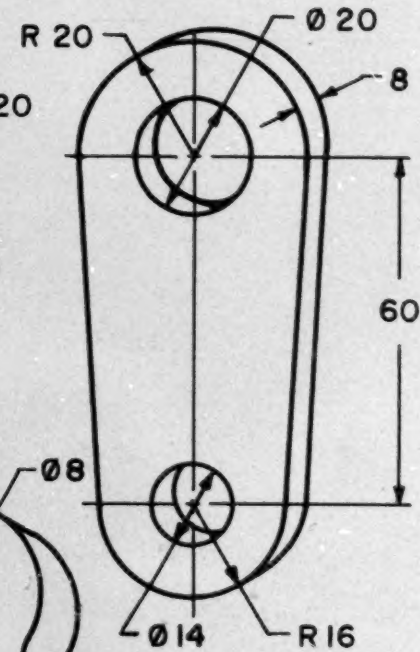
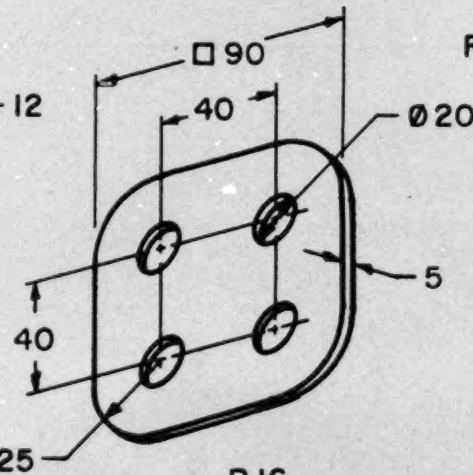
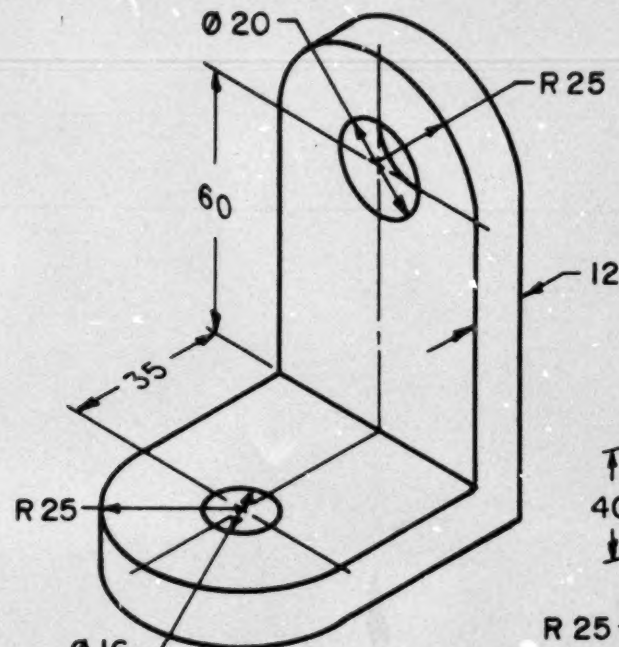
TWO VIEWS



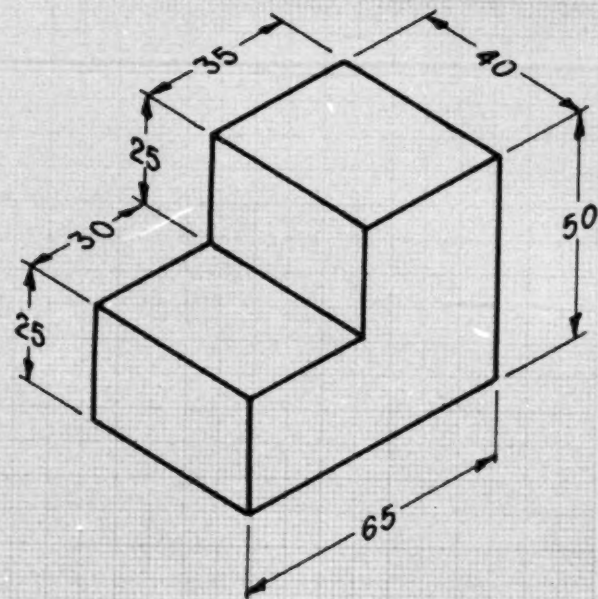
TWO VIEWS

ALL DIMENSIONS IN mm

DRAW FULL SIZE, TWO OR THREE
VIEWS OF EACH OBJECT.
ADD DIMENSIONS.

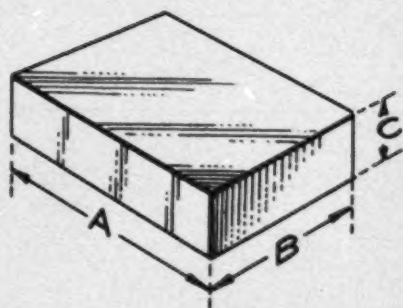


ALL DIMENSIONS IN mm

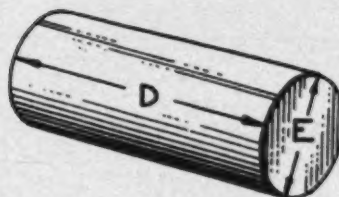


Convert the decimal inch dimensions shown below to millimetres (rounded to the closest 0.5 mm), and record the results on the attached sheet.

Part No.	A	B	C	D	E
1	1.25	1.0	0.375	0.750	1.5
2	2.50	2.0	0.750	1.500	3.0
3	0.9375	0.75	0.281	0.5625	1.125
4	0.625	0.5	0.1875	0.3750	0.750
5	3.750	3.0	1.125	2.250	4.5
6	5.00	4.0	1.5	3.0	6.0
7	0.625	0.5	0.187	0.375	0.75



PART NO.	DIMENSION		
	A	B	C
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			



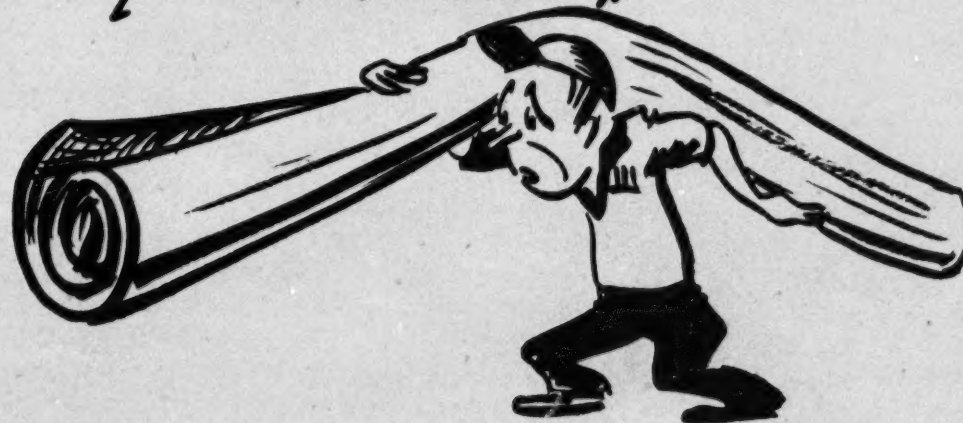
PART NO.	DIMENSION	
	D	E
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		



LEARNING METRICS--LENGTH

- | | |
|---------------------------|--|
| Stage 1 -- Conversion: | 1 centimetre is 0.393 7 inches |
| Stage 2 -- Comparison: | There are about $2\frac{1}{2}$ centimetres in 1 inch |
| Stage 3 -- Comprehension: | Your index finger is about 1 centimetre wide |
| | Your clenched fist is about 10 centimetres wide |

"...20 square **WHAT** *?"



LEARNING METRICS- -AREA

- Stage 1 - - Conversion: 1 square metre equals 1.196 square yards
- Stage 2 - - Comparison: 1 square metre is about 20 percent larger the
1 square yard
- Stage 3 - - Comprehension: The floor of the shower stall is 1 square metre
The carpeting needed to cover a room 4000 x 5000 mm
is 20 square metres



LEARNING METRICS- -WEIGHT (MASS)

- | | |
|----------------------------|---|
| Stage 1 - - Conversion: | 1 kilogram equals 2.205 pounds |
| Stage 2 - - Comparison: | 1 kilogram is about 20 percent more than 2 pounds |
| Stage 3 - - Comprehension: | A steak for two weighs 1 kilogram |
| | A large Thanksgiving turkey weighs 10 kilograms |
| | A heavyweight boxer weighs 100 kilograms |

PRESSURE--a force acting over a specified area

--force is the newton (N) and area is the square metre (m^2)

--1 pascal (Pa) is the pressure produced by a force of 1 newton applied, uniformly distributed, over an area of 1 square metre

--a pascal is a very small unit, therefore, pressures are expressed in kilopascals (kPa)



Examples of Pressure:

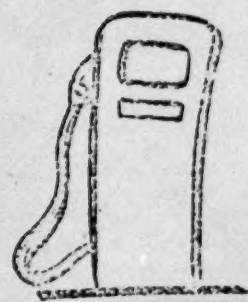
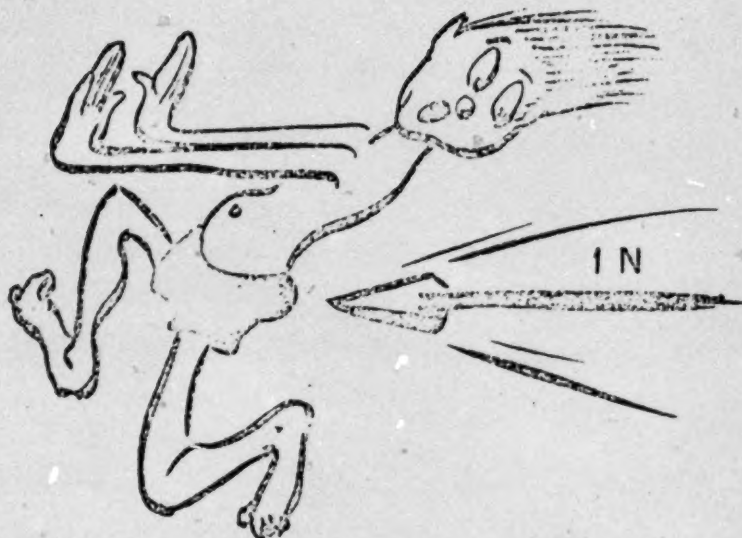
100 kPa is standard atmospheric pressure

200 kPa for average car tire

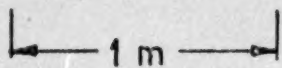
400 kPa for bicycle tire

550 kPa for shop air pressure

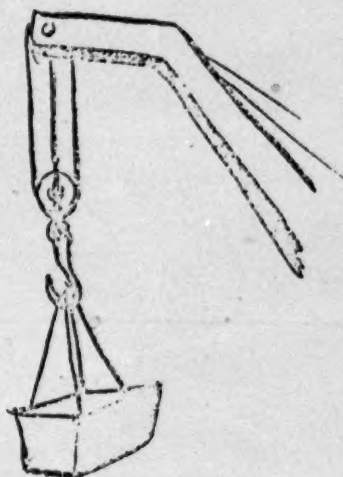
24 000 kPa is maximum for oxygen gas tank



HEAT
ENERGY



ELECTRICAL
ENERGY



MECHANICAL
ENERGY

Examples of Energy and Work:

8000 kilojoules (kJ)-a typical daily diet

1 Btu is about 1 kilojoule

1 kg lump of coal has energy potential of
about 23 000 kilojoules